THE EAST AFRICAN AGRICULTURAL JOURNAL

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EDITORIAL NOTES

On another page we print a question of some importance raised by an Agricultural Officer in Tanganyika Territory. Why, under certain circumstances, are soils that have been uncultivated for a number of years unable to produce a grain crop during their first year or two under cultivation, although they are quite capable of giving good yields from other crops, such as legumes or cassava?

Following Mr. Rounce's query are some notes by the Soil Chemist, Amani. From these it will be apparent that the problem is by no means fully understood, nor is it likely to be a simple one.

It would be of interest and value to publish the experience of others, in different districts, not only concerning the failure of grain crops on newly broken land, but also of instances where a good yield has resulted. Details of the type of soil, the previous covering of vegetation, and the method of preparation of the land should be given. The correlation of a number of well-attested examples, supported by the necessary data, would do much to elucidate this question in particular, as well as some of the problems of shifting cultivation in general.

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DERRIS.

Considerable interest continues to be taken in the cultivation of Derris in East Africa. We are continually receiving, at Amani, requests for planting material, all of which have at present to be refused, since there is no material available beyond what is required for a large-scale demonstration experiment on the possibilities of Derris as a commercial crop in East Africa.

In this issue we print an article by Mr. C. B. Garnett on the cultivation, harvesting and preparation of derris root, based chiefly on information obtained from Malaya, which is at present almost the sole source of the commercial product.

So far as we are aware, *Derris malaccensis* does not at present occur in East Africa, and it would not appear to be desirable to introduce it, for fear of its being used, intentionally or not, to adulterate the higher rotenone-yielding *D. elliptica*. Similarly, there appears to be nothing to be gained by introducing other strains of *D. elliptica*, seeing that the one already under trial at Amani has an exceptionally high rotenone content, and that no better strains are known to exist.

If present expectations are fulfilled, supplies of cuttings should be available for distribution in about eighteen months from now, shortly before when we hope to publish further articles on the subject in the light of locally gained experience.

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YAMS.

The natives of East Africa are somewhat conservative in their diet, though perhaps, when one considers the suspicion with which the average Englishman regards snails or the Frenchman tea, no more so than European peoples. The advantages of a more varied diet are frequently stressed by the medical profession, while the value of alternative food-crops becomes particularly evident in times of drought and locust invasion. In many parts of West Africa and India, as well as in other countries, yams form the staple carbohydrate food of the native population. Nor are they to be despised by Europeans. Many of the better varieties compare favourably, at least for a change, with the English potato. Yams are at present grown on a small scale in a few districts in East Africa, but it seems that nowhere have they become popular. The origin of such varieties as exist appears obscure, and it is by no means certain, and indeed unlikely, that they are the varieties most suitable for the conditions.

True yams belong to the genus *Dioscorea*, which contains a large number of species distributed throughout the tropics and of these several are cultivated. Of the cultivated species, the most important are *D. alata* and *D. rotundata*, the stems of which twine counter-clockwise, and *D. esculenta*, which climbs clockwise. (It should be noted that in parts of America sweet potatoes (*Ipomaea*) are sometimes erroneously called yams.)

Although capable of standing up to fairly long periods of drought, yams require a comparatively heavy rainfall, which, in most places where they are successfully cultivated, is of the order of 50 inches a year and upwards.

There are therefore wide areas of East Africa in which it is unlikely that they would be an economic proposition, but, following a recommendation made at the Agricultural Conference held at Amani in February last, endeavours are being made to introduce a large number of varieties for trial at Amani and ultimate distribution.

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The annual report for the year 1934 of the Department of Agriculture, Kenya Colony, which has recently been received, is published, as an innovation, in three volumes. Volume I contains the Director's report on agricultural progress during the year, also the reports of the Deputy Directors of Plant and Animal Industry. These two latter are, in effect, summaries of the full reports by the

specialist and field staff of the two Divisions, which are given in detail in Volumes II and III respectively.

It is clearly difficult to write even the most sketchy review of a publication, the three volumes of which, containing some 350 pages, are in themselves practically a review of the multifarious activities of a large and progressive department.

Reports of Agricultural Departments are doubtless read by most of those interested—whether agricultural officers or farmers—in their own particular territory. It is, however, perhaps the function of a Journal such as this to call the attention of those in the neighbouring countries to the mass of information, much of which will be found of interest to them, that is obtainable, at no great cost, in a report such as this.*

* * * *

The Editor invites correspondence on any subject of agricultural interest in East Africa. Letters should be reasonably brief, and preferably signed or at least initialed. In any case, correspondents must give their full name and address, even if not for publication.

No communications from "Pro Bono Publico" (or, for that matter, even signed letters) that have any reference to political questions can be considered.

Probably the most valuable aspect of a correspondence column in an agricultural journal would be the giving of, and requests for, useful hints on a variety of matters connected with farming in the tropics. There must be many farmers and agricultural officers in East Africa who are in possession of some little bit of information that might be of great value to others, and, conversely, many who would be glad to ascertain the experience of others on some particular question.

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TUNG OIL.

We have been asked to give publicity to the following circular letter, received from the Advisory Committee on Oils and Oilseeds of the Imperial Institute. The letter has already been sent direct to those known to have been experimenting with the growing of *Aleurites*, but it is possible that it has not reached all who are interested:—

ADVISORY COMMITTEE ON OILS AND OILSEEDS.

SUB-COMMITTEE ON TUNG OIL.

Imperial Institute,
London, S.W.7.
15th June, 1936.

Dear Sir,

The Marketing of Tung Nuts.

The Imperial Institute is aware that during the last few years you have been carrying out experimental trials in the cultivation of Tung trees. It is anticipated that by this time your trees are probably producing fruits and that you may be harvesting a crop large enough for you to be desirous of offering the nuts for sale on the market.

In this connection the Imperial Institute foresees that you may experience some difficulty in disposing of your crop until such time as Tung nuts have become a regular article of commerce. In order to overcome this difficulty, and to assist growers to sell their produce, the Imperial Institute Sub-Committee on Tung Oil has made an arrangement with Tung Oil Estates, Ltd., Tavistock House (North), Tavistock Square, London, W.C.1, whereby the Company is prepared to pay the grower for quantities of Tung nuts, of not less than one-ton lots, c.i.f. United Kingdom port, the following prices per ton based on the London spot price of oil per ton at a date two months after leaving the port of shipment:—

* To be purchased from the Government Printer, Nairobi: Vol. I, General, Sh. 2/50; Vol. II, Division of Plant Industry, Investigational Work, Sh. 2/50; Vol. III, Division of Animal Industry, Investigational Work, Sh. 1.

London Spot Price of Tung Oil Per Ton	Price Payable for Tung Nuts of Fair Average Quality Per Ton *c.i.f.* United Kingdom Port
£	£
45	9
55	11
65	13
75	15
95	19

When the price of Tung oil varies between the above prices the nuts will be paid for *pro rata.*

The above-mentioned prices will be applicable for twelve months from this date of issue of this letter, after which they will be reviewed from the experience obtained.

This offer is made for Tung *nuts* and not for the fruits. The husks should therefore be removed from the fruits before shipment and only the nuts, complete with their thin woody shells, forwarded to the firm mentioned. The nuts should not be more than six months old.

If you should desire to avail yourself of this arrangement, you are asked to communicate direct with Tung Oil Estates, Ltd., who will furnish you with details as to shipment. When writing to the Company the species of Tung grown should be stated, i.e. either *Aleurites Fordii* or *Aleurites montana.*

In the event of your not having one ton of nuts for disposal, it might be possible for you to co-operate with other growers in your district and to combine the produce from the respective estates with a view to the collection of a total quantity of at least one ton of nuts. *A. Fordii* nuts should not be mixed with those of *A. montana.*

My Committee desire to keep in touch with all developments in connection with the Tung industry, and I shall therefore be glad if you will kindly inform me of any action you may decide to take in connection with the above offer.

Yours faithfully,
G. T. BRAY,
Secretary to the Committee.

Review

THE CULTIVATED RACES OF SORGHUM, by J. D. Snowden, F.L.S.: The Trustees of the Bentham-Moxon Fund, Adlard & Son, Ltd., London; pp. vii and 274, with four plates and thirty text figures, 1936; 10/6.

This book is the first attempt that the authorities of the Royal Botanic Gardens, Kew, have made to carry out a systematic and detailed crop study in co-operation with the Agricultural Departments of the British Empire.

The work was carried out at Kew on botanical specimens loaned from different herbaria in all parts of the world and on material together with observations supplied by officers of the Departments of Agriculture in the British Empire.

The author, Mr. J. D. Snowden, at one time Economic Botanist in the Uganda Protectorate, is to be congratulated on completing such a critical and difficult piece of work in the short space of three years.

Kaffir corns, better known in East Africa as mtama, are known under the general botanical name of *Andropogon Sorghum* or *Sorghum vulgare*, and anyone who has had anything to do with the cultivated sorghums knows there are a number of distinct species under these names, not only that there are a great number of varieties and forms.

An analytical key is given to the subseries and species recognized. Each species is very thoroughly discussed with references to literature, synonymy, history, botanical description, characteristics, affinities, distribution, cultural and economic notes.

The species are further amplified by descriptions of varieties and forms. To take a random example, *Sorghum caffrorum* Beauv. has thirteen varities to which a botanical key is given, and some of the varieties have as many as seven forms.

Grain-colour has been used as a useful varietal character by most workers in describing the cultivated sorghums, and it has been used in this book. The majority of forms have also been distinguished by means of grain colour; the colour standards used in the revision are those in R. Ridgway's *Color Standards and Color Nomenclature* (1912).

In the absence of any clear-cut botanical distinctions amongst some of the varieties and most of the forms of this very difficult group of plants, colour differences appear to be the next best character to use. It should, however, be remembered that the colour of grain in the field, when the grains are ripe and fresh, may be of a very different shade from that which will be assumed after the grains have been stored in a herbarium for a number of years.

The plates and text figures, the latter by Miss S. Ross-Craig and Mr. G. Atkinson, illustrate the fruiting heads and grains of the principal sub-series and some of the varieties. There is also a diagram illustrating the probable relationships of the wild and cultivated races of sorghum.

The wild African sorghums of the subsection Arundinaceae are most abundant in tropical Africa in regions where sorghums are grown as a native food crop, and they readily intercross with the cultivated ones.

The relationships of the wild and cultivated sorghums are discussed, and ten species of the former are also described and their geographical range given. The author says that there seems no adequate reason why tropical Africa should not be accepted as the ancestral home of the cultivated sorghums.

He further suggests that the wild *S. arundinaceum*, *S. verticilliflorum* and *S. aethiopicum* are primarily (and *S. Sudanense* to a certain extent) concerned in their origins and these are connected with the evolution of the cultivated races as recognized by the author.

Besides the references given in the general text, the bibliography, which, it is stated, is not complete, comprises thirteen pages of references, dating from A.D. 60-70 to 1935. It is classified as General, including Classification and History; Grain Sorghums; Cultivation, Uses, etc.; Saccharine Sorghums; Broom-Corn Sorghums; Fodder Sorghums; Anatomy, Morphology and Physiology; and Poisonous Properties of Sorghum.

Indexes then follow, with botanical names, vernacular names, countries and regions, thus completing 274 closely printed pages, packed with information about the botanical history and classification, botanical descriptions with enumerations, and general distribution of the cultivated races of sorghum.

P.J.G.

Poultry Progress at the Kizimbani Experimental Station, 1932-1935

By F. B. WILSON, *Agricultural Officer, Zanzibar.*

INTRODUCTION.

A journey taken through any part of Zanzibar will quickly indicate to an observant person that the keeping of poultry is almost universal amongst the native population. It will be equally evident that the type of poultry is generally entirely mongrel, small and poor, ill housed and little cared for. Therefore it is not surprising that the eggs for sale in the markets are very small, dirty, and of doubtful freshness, whilst the carcasses of these native birds are small and the flesh tough. Prices of poultry and eggs are very low, and little or no business is done with the large number of ships which are constantly passing through the Port of Zanzibar. No improvements in breeding, feeding or housing have been carried out in the past. Various town residents have done well with small units of European fowls, but up to the present there has been no serious organized attempt to improve the poultry of Zanzibar.

There is little doubt that there are great possibilities in an improved poultry industry in this Island. From the point of view of the health of the inhabitants, increased consumption of poultry and fresh eggs would do a great deal towards balancing what is at present a protein-deficient diet in many inland districts. Poultry might also become an increasingly important cash-earning part of the smallholder's enterprise. Zanzibar is particularly fortunate in having such an extremely well developed road and transport system, which is merely waiting to be used for the quick transport of fresh perishable products such as eggs. A vast amount of shipping passes through the Zanzibar harbour, all requiring a very large amount of poultry products, and yet it will only be when fresh, high quality, graded produce is for sale that this big potential market can be tapped.

Naturally, it will take a long time to effect such improvements as are outlined above, but if high-class breeding stock is made available, information on feeding and disease control given, and general propaganda work carried out, especially in schools, a sound foundation of a new industry will have been laid. Much of the pioneer work in other countries was carried out by enthusiastic individuals, until work was seriously undertaken by research institutions. Most of the fundamental problems of feeding, rearing and breeding have now been carefully worked out. We, in Zanzibar, are in the fortunate position of having all this basic information in our hands, and it is now our duty to apply these scientific principles and observe their working under local conditions. A start in this work of improvement was made in October, 1932, when two pens (18 hens and 2 cockerels) of the Rhode Island Red breed were imported from Kenya. Since that time the unit has been greatly increased in size, improved rations have been tried, new houses designed, and various other problems investigated. It is the purpose of the present paper to review the progress of the three years' work, 1932-1935, and to put forward for consideration one or two suggestions for future policy.

General Management.

For the first few months, the newly imported birds were temporarily accommodated on a site near the Kizimbani main buildings. The only feature which this site had to recommend it was that of proximity to the main buildings, otherwise it was too thickly populated by clove trees, grew no grass in the runs, and was not infrequently visited by marauding animals at night. Early in 1933 the unit was moved to a new site near Kinuni Mdo, where the poultry-keeper took up residence in a house with food store attached, and a planned lay-out of large grass runs, breeding pens, rearing area and isolation pen was gradually built up.

The object in adopting this lay-out was to provide sufficient accommodation for 400-500 laying birds in units of 100, and to provide space for eight smaller breeding pens where units of eight hens and one cock could be accommodated. The size of run is based upon the figure of 300 birds per acre for semi-intensive accommodation.

The question of shade is one of importance, and the original runs had to be equipped with low palm-thatched shade in one portion. This has the disadvantage of being expensive and affording a hiding-place for vermin, but is useful in providing an absolutely dry shelter during heavy rain. In the majority of runs this shade has now been replaced by a natural one formed from coppiced poles of *Gliricidia maculata*. Poles of 8 to 10 feet in length are planted 2½ feet deep, and the top sprouts allowed to develop. Periodically these are pruned at the ends, and in the course of twelve months a very useful shade has established itself. Pruning is important to maintain a compact bushy form, the natural habit of the plant being to produce very long slender branches.

By far the best grass species for establishment in the runs has been found to be Doub grass (*Cynodon dactylon*). This grass, with its creeping habit, forms a thick carpet, which will stand any amount of wear by poultry, and is a constant source of fresh green shoots. It seems generally necessary to hoe up the whole area in wet weather, and establish the grass by cuttings spaced 1 foot by 1 foot. Poultry are so fond of this species that it is generally necessary to give two or three months for establishment before allowing them access.

The question of housing has been studied and a suitable type of house for prevailing conditions has been evolved. The main points of a good house are: Cleanliness (ease of cleaning and disinfecting), good supply of light and air, rain protection and coolness, low cost, durability, and easy portability. The old type of house was unwieldy, expensive and difficult to clean. The usual type of native poultry house has the advantage of protecting the poultry from animal attack, but is impossible to clean and offers every chance for the propagation of disease germs. Although cheap to build, it is not durable. Plate 1 shows the type of house now being produced and used at Kizimbani. Inside measurements are 6 ft. by 4 ft. (floor) and 4 ft. high at the ridge. The floor is of strong 1 in. mesh wire netting, on which is laid a framework of slats for the poultry to roost on. The house incorporates fairly exactly all the good points enumerated above. The house, which costs approximately Sh. 60, is very durable and easily transported. All the poultry droppings go through the wire netting and are swept off the ground each morning, or else the house may be moved about the run at regular intervals. The whole of the woodwork is treated with solignum, and this process

is regarded as an annual routine in preserving and disinfecting the house. Spraying with disinfectant at other times is a very simple business.

An important part of the lay-out is the provision of an isolation pen. This pen, which is 10 yds. by 25 yds., is provided with a single small house and covered shade. When the poultry-keeper opens up the houses in the morning, any birds which are seen to be in any way sick are at once removed to this pen. Since use has been made of this pen, no disease has spread to any appreciable extent amongst the adult fowls.

PLATE 1
New type Fowl House

REARING.

The early part of a hen's life is most important, in that its adult performance as an egg-producer will depend largely upon its care and feeding during the growing period. For this reason, some of the points of management which have given success at Kizimbani are enumerated below.

In the choice of eggs for setting, only well-shaped eggs of 2 oz. weight are used. Experience seems to indicate that there is a serious decline in the fertility of eggs after a period of six days. The eggs used for setting are therefore as fresh as possible. Since pullets come into lay at about 6 to 8 months old, it is considered that eggs obtained from birds of 12 months of age are most suitable for setting. It has not yet been possible to carry out routine trap-nesting, so that the breeding pens are made up of birds selected by handling and appearance.

Nests are always made with a foundation of earth and completed with a small amount of fine dry grass. Both setting hens and nests are given an initial dusting with insect powder. The ordinary routine practices for sitting hens are observed, i.e. let out for 20 to 30 minutes each day in the early morning, fed with grain only and given water and access to a dust bath. The number of eggs set is

12 to 15 under European hens and 9 under native hens. Native hens used have proved both excellent sitters and mothers.

One point which is emphasized in rearing is the desirability of hatching out a large number of chicks together. This plan greatly facilitates the feeding of different rations during stages of the growing period, and is most useful when culling of the poorer chicks is advisable. Thus, whenever possible, four or six hens are set approximately on the same date, and on hatching it is not difficult to make one hen the foster mother of 30 to 40 chicks. This is done by introducing all the chicks to one of the mothers at night on the first or second night after hatching. A practice which is always used at Kizimbani is that of chalking the date of hatching above the door of each coop as soon as the eggs are set.

After the hatch is completed the chicks are left for 12 hours before receiving any food. This has proved to be more satisfactory than the former standard practice of a 24-hour fast. The first feeds, which are given at three-hour intervals (five feeds per day), are of hard-boiled egg chopped fine. Gradually, after three or four days, fine grains and mash are introduced, and finally replace the more expensive egg feed. Quantities given are as much as the chicks will quickly clear up. Feeding is done in shallow wooden troughs, and it is especially important as the chickens grow up that there should be ample trough room, so that weaker birds are not deprived of their food by their stronger companions.

Culling is carried out three times. The first culling is that of weakly poor chicks and obvious "bad doers" during the first six weeks of life. Secondly, the sexes are separated at approximately 12 weeks old, and this operation is used as an opportunity for further exclusion of unthrifty growing birds. The final culling is at 12 months, when the breeding pens are selected. Both cockerels and hens are thus culled, and the birds which are discarded from the flock are fattened and sold off as soon as possible.

During the growing period of 4 to 16 weeks, up to 20 per cent fish-meal is included in the ration, to promote strong vigorous growth. After this the proportion is reduced to 10 per cent or even less, in order that birds should not mature too early. The object always in view is the production of large-bodied strong hens, and very early laying is likely to prejudice the attainment of this object. The young birds are accommodated in houses built upon the "Sussex Night Ark" principle, and appear to thrive exceptionally well. They are given ample supplies of green food, and care is taken that their full mineral requirements are met.

Feeding.

It is in the realm of scientific feeding that one of the greatest advances in poultry-keeping in Zanzibar can be made. It was stated in the introduction that little, if any, food was provided for poultry in Zanzibar. What feeding is given is unbalanced, and is deficient in that most important constituent for egg production—proteid. Cereal foods such as maize, sorghum and rice, which form the basis of poultry feeding is Zanzibar, are all rich in carbohydrates but poor in their proteid content. How is this deficiency to be made good? This was the problem of most importance at Kizimbani after the pen of fowls had been fed for six months on an almost exclusively cereal ration and egg-yields had dropped to practically nothing. The obvious source of proteid food in Zanzibar is the abundant fish supply. One of the two pens of fowls was put on to a ration con-

taining 10 per cent fish, and almost at once showed great improvement. Egg-yields more than doubled, and it was considered that the result justified placing all the fowls on this ration. Egg-yields for the six months before and after the change of ration illustrate clearly the great improvement effected.

TABLE I

SHOWING EGG-YIELDS FROM 16 BIRDS FOR TWO THREE-MONTHLY PERIODS BEFORE AND AFTER THE INTRODUCTION OF A BALANCED RATION

ORDINARY RATION		BALANCED RATION	
Oct.-Dec.	Jan.-Mar.	April-June	July-Sept.
287	191	465	483

It might be argued that climatic factors were also important. The months of October to March are certainly the least favourable for egg production, but a further complete year's records on a single ration show that standard deviation in egg-yields due to time of year is not more than ± 5.5 per cent.

Starting with the month of April, 1933, a systematic time-table of feeding was inaugurated. It is as follows:—

6 a.m.—Grain feed of ½ oz. per bird; fresh water and green food.
10 a.m.—Mash feed of 2 oz. per bird.
5 p.m.—Grain feed of 1½ oz. per bird.

The grain feed is altered from day to day, thus ensuring good variety; maize, sorghum and bullrush millet are used. The quantities of grain and mash fed are based upon the Ministry of Agriculture's figures. It is of course a big assumption to make that quantities recommended for use in England should be exactly right for the tropics. It can only be said that the experience of two years has shown the feeding to be very nearly right. The birds keep in fine condition, and egg-yields are steadily improving.

TABLE II

SHOWING AVERAGE YEARLY EGG-YIELDS OF RHODE ISLAND RED HENS AT KIZIMBANI

	1933	1934	1935*
Average number of birds	17	29	45
Average yield per bird ..	109	139	152

*Based upon January-September figures.

The mash finally adopted as a basic ration for the poultry unit is as follows:

Bran	3 parts
Maize meal	1 part
Millet meal	1 part
Coco-nut meal	1 part
Dried shark	10 per cent
Salt	1 per cent

It is noteworthy that all the above foods are obtained locally.

The various parts of the ration are measured out and mixed once a fortnight, so that the poultryman just takes so much mixture each day for feeding.

Requirements for lime are met by the provision in each run of a box of crushed oyster-shell. These shells are obtained locally for the cost of collection only. Shark was found to be by far the most economical and useful type of fish. A large quantity of dried shark (200 lb.) is purchased when supplies are plentiful and cheap. It is cut up and boiled to soften, and then put through an ordinary mincing machine. The resulting mince is rather sticky, including as it does skin and bone, and is therefore dried off with a small amount of bran. It is then placed on mats in the sun to dry thoroughly. The final product is powdery and dry, has practically no smell, is easy to handle and mix in rations, and will keep almost indefinitely. When 10 per cent fish-meal is fed in the ration there is no appreciable

flavouring whatever in eggs or poultry flesh.

Breeding.

Breeding work has followed two main lines: (1) Breeding for improvement of the Rhode Island Red stock; (2) Cross-breeding the Rhode Island Red with selected native stock.

It was obvious when the first batches of chickens were reared in 1933 that the original imported stock was not quite pure. Many of the offspring had light-coloured and even white feathers, especially on the wings and neck, whilst other birds showed distinct head characteristics of the Leghorn breed. The policy which has been followed is that of throwing out all birds which are not true to type, selecting from the true type pullets bred in Zanzibar, and mating them with the best obtainable pure-bred stock cockerels from Kenya. It is noteworthy that the 1935 hatch shows far greater uniformity in colour than those of 1934 or 1933. This policy in time is bound to build up a fine pure strain of birds. The size of pen for breeding is 8 pullets to one cockerel. The fertility of eggs set at Kizimbani during 1935 has been about 76 per cent.

Plate 2 shows the results which have been obtained in the Rhode Island Red (cock) x native (hen) cross-breeding at Kizimbani.

The work of cross-breeding offers very great promise for improvement. It may be possible to combine in a single breed the good points of both the native and the Rhode Island Red breeds. The good features of the native bird are: hardiness (which may be accompanied by a certain degree of resistance to disease), and ability to forage for itself. The main features which it is desirable to pass on from the Rhode Island Red breed are: early maturity, high egg-yielding capacity, large carcass with abundant meat. The fact that this ideal is to a large extent obtainable is clearly indicated by the photographs (the background grid is in one-inch squares). It is, however, quite clear that breeding and improved feeding are complementary in the pursuit of this ideal. It is of little use distributing first-class stock cockerels to natives who will not improve their methods of feeding. This question is ultimately largely one of economics, and will therefore be dealt with later.

The best time of year for hatching and rearing has been the subject of some investigation. As the numbers of stock are yet small the following remarks are from observation only, and have not yet been confirmed by mortality and growth statistics. Growth is quite obviously best during the cooler months of the year; early hatching is therefore advisable. At the same time, the cold and wet associated with the Great Rains (April and May) may have a very adverse effect upon growth. In June, 1935, up to 90 per cent of certain batches of chicks hatched in May were lost owing to contagious colds. Mid-May to the end of June is considered to be the ideal time for hatching, whilst earlier hatched chicks should have ample warm shelter from the wet weather. The Rhode Island Red breed matures in six to eight months.

Diseases.

The extent of disease in the Kizimbani unit has been small, but a few notes on diseases which have been encountered in travelling about the Island may be of value.

The most serious disease which has appeared in the last three years has been that of fowl cholera. No doubt it is constantly latent amongst the poultry population of both islands, and flares up at

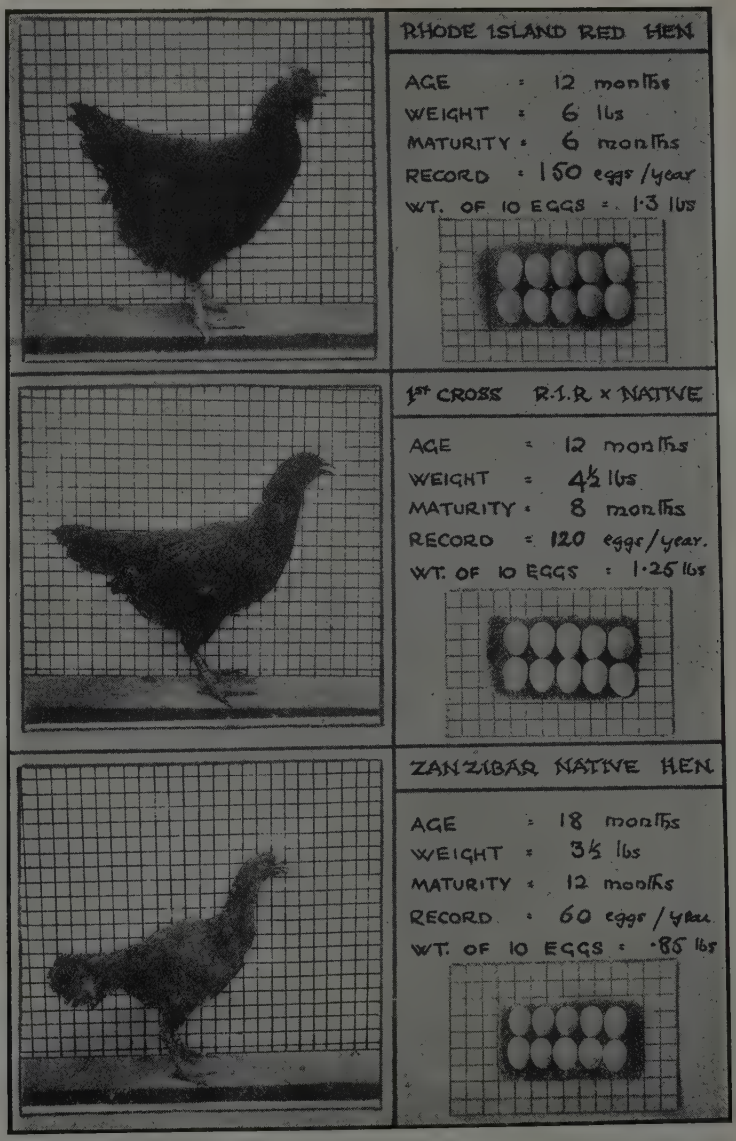
RHODE ISLAND RED HEN
AGE = 12 months
WEIGHT = 6 lbs
MATURITY = 6 months
RECORD = 150 eggs/year
WT. OF 10 EGGS = 1·3 lbs
1st CROSS R.I.R. x NATIVE
AGE = 12 months
WEIGHT = 4½ lbs
MATURITY = 8 months
RECORD = 120 eggs/year.
WT. OF 10 EGGS = 1·25 lbs
ZANZIBAR NATIVE HEN
AGE = 18 months
WEIGHT = 3½ lbs
MATURITY = 12 months
RECORD = 60 eggs/year
WT. OF 10 EGGS = ·85 lbs

PLATE 2

The above illustrates results which have been obtained in breeding work on the Kizimbani Experimental Station. Egg records refer to breed averages and not to the individuals photographed. The background grid is in one-inch squares.

intervals. A serious epidemic started in Zanzibar at the beginning of 1935 and lasted about six months. It would not be a rash statement to say that the fowl population was literally decimated by the epidemic. There are instances where flocks of 200 to 300 head of poultry all died. At the present time (October, 1935) there is a general scarcity of poultry and eggs. It is not within the scope of this paper to describe symptoms and cure, as these are accurately described in available textbooks. Suffice it to say that the only poultry which escaped were those in very isolated communities (e.g. Bwejo on the east coast) and those at Kizimbani, which were equally well protected from sources of disease by wire netting and the use of disinfectant. There is no doubt that the disease is largely propagated through birds bought and sold in the markets, and could to a large extent be controlled by legislation preventing the internal as well as the external movement of poultry.

A serious disease to which young chickens are particularly prone is fowl pox (Epithelioma). There appear to be two forms—a mild form which is generally confined to nodules on the face and comb, and a more serious form associated also with lesions in the mouth and roup. It is the mild form that has generally been met with in Zanzibar. Although quickly yielding to a simple treatment, this disease causes heavy mortality amongst young chickens in Zanzibar, and the fact that no chickens are kept isolated by wire runs means that contagious spread is rapid and general.

Favus, or "white comb", has been seen on cockerels at Kizimbani, but has yielded to the recommended treatment of antiseptic cleaning of the affected places and the application of sulphur ointment. Colds have been responsible for deaths of chicks, but these are largely preventable by shelter during cold damp weather. Tuberculosis and liver disease complete the list of diseases which have been met in the past three years.

The native appears to know practically nothing about poultry diseases, their origin, nature or cure. Good housing and isolation are both necessary before any big improvements can take place. The money losses incurred as the result of the fowl cholera epidemic would have paid for many good houses and wire-netted runs and proper disinfection.

Economics.

It was remarked earlier that the problem of poultry improvement was largely one of economics. No matter how desirable it may be to have fine hens laying a large number of good-sized eggs, good houses and disease-free flocks, it is not until the poultry-keeper can be convinced that these improvements actually bring him in a greater profit from his outlay that he will begin to show an interest in their adoption on his own holding. In many districts eggs are sold at 2 or 3 pice each, and with the present low purchasing power of the community it is not likely that better eggs would command a better price. On the other hand, the town market could without doubt absorb a large number of eggs at a somewhat better price if the quality were better. There is also the possibility of a trade with ships. The present method of poultry-keeping is in many ways economically sound, for although the poultry-keeper gets very small return from his miserable stock of mongrel hens and cockerels, he expends almost nothing on food or housing, so that his gross income is practically the same as his net profit.

One of the first steps which must be taken is that of putting the Kizimbani poultry unit on a sound economic basis.

It is clear that having separate breeding pens, recording and marking eggs, and the many extra jobs associated with a unit of this type, add considerably to the "costs" side of the balance-sheet, and yet there seems no reason why the Kizimbani unit could not be a really paying concern. It would be of little value to quote figures for expenditure and receipts for the past three years, for these are complicated by the main object, which has been to increase the size of the flock. It is sufficient to say that the present labour staff would be quite capable of dealing with a unit of 500 to 600 laying hens. All that is required is some additional housing accommodation. When the unit is this size it is almost certain to become economic. Overhead charges must be spread over the largest number of hens.

From the point of view of the improvement of native poultry-keeping, the process will of necessity be a slow one. In order to increase the sales of eggs in the town it will be necessary to foster public confidence by the gradual establishment of grades in the market. This may take years to accomplish, but it is the only finally satisfactory way of dealing with products which are irregular both in size and quality. A premium for large fresh eggs and good quality birds must be established. As soon as this policy begins to reflect in increased consumption and therefore better prices, there is no doubt that the industry will rapidly develop. Only two instances of the powerful effect of good prices upon increased efficiency in production are necessary. First, the case of native-grown tobacco. This has for long been a "hidden export" from various parts of Zanzibar. Prices during the last two or three years have been good, with the result that an ever-increasing area is being planted to this crop, and it is surprising to what trouble the growers will go to obtain good yield and quality. The other example is that of native-produced vegetables, which were most difficult to obtain in the town market a year or two back, and prices were high; at the present time large quantities of good quality produce are almost contantly available. Price improvement for better produce will lay the foundation for a general development of the poultry industry of Zanzibar.

In the initial stages various individuals must be encouraged to make improvements. Already a number of people who have purchased stock cockerels are selling eggs for setting at an enhanced price. Such folk must be persuaded to invest a part of their profits in further improvements in feeding and housing. Mortality of chicks raised in the country districts is surprisingly high, and the introduction of better houses which could be kept clean, together with small wired-in runs for chicks, would at once reflect a greater return to the owner. The initial impetus will have to come from trained staff of the Department of Agriculture engaged in district work, but when once the improvement has started it will largely grow by itself. It might be pointed out that properly run school poultry units could play an important part in propaganda work.

Extension Work.

For the most part work has been confined to the building up of a poultry unit at Kizimbani and experimental work, which has already been described. However, a start has been made in trying to introduce improvements to various people in Zanzibar. The various pieces of extension work are described below:—

Sale of Eggs for Setting.—During the period under review some 2,166 eggs

have been sold to Arabs, Indians and Africans for setting purposes. The price of eggs, which was originally 37 cents each, has been reduced now to 14 cents, so that first-class setting eggs are now available in quantity at a most reasonable price. It is gratifying to notice that the reduction in price recently effected has greatly stimulated demand from the public.

Sale and Distribution of Stock Cockerels.—Altogether 110 stock cockerels have been sold or distributed free. The price has been Sh. 6 per bird. Some 24 cockerels were given free to citrus-growers in the Ndijani, Kwambani and Upenja districts in return for their willing co-operation in the collection of citrus budwood for use at Kizimbani.

Lectures, Demonstrations and Advice.—Six lectures on poultry-keeping were given to the twenty-two rural school teachers who attended the vacation course, July-August, 1935. Full notes of these lectures are attached to the report on the course. A small demonstration of housing, breeding and feeding was staged at the Horticultural Society's show at the Victoria Gardens on 26th September, 1935. A number of inquiries with regard to general poultry-keeping have been received and dealt with. It was possible to increase one poultry-keeper's egg-yields fourfold without increase of cost.

Published Articles.—The following articles were prepared and published in the *Mazungumzo ya Walimu wa Unguja*:—

(*a*) The Management of Poultry.

(*b*) The Feeding of Poultry.

(*c*) The Rearing of Chickens.

(*d*) A Serious Poultry Disease in Zanzibar (Fowl Cholera), published in the *Samachar, Al Falaq,* and the *Zanzibar Voice.*

Some Proposals for Future Maintenance and Experimental Work.

Housing.—The great objection to the adoption of improved houses by the native is their somewhat prohibitive initial cost. A very promising line of work would be to take the present native house as a basis and experiment with simple improvements which would render the house clean and accessible. The use of some wire-netting would almost certainly be necessary.

It would be of great value if the construction of sound poultry houses were included as a part of the training in the carpentry classes of the Education Department. There is no doubt that even at present there is a market for such types of houses.

Incubation.—Further reliable data on the viability of eggs after various periods is needed. It is possible that eggs may remain viable very much longer during the cool season. Controlled conditions would be obtained by the use of the incubator.

Feeding.—The ration at Kizimbani has proved reasonably sound, but it has the disadvantage of being expensive. As soon as the flock has reached such a size that pens can be set aside for ration experiments these should be started, using the standard Kizimbani ration as a "control". In the mash part of the ration the following alterations are suggested:—

(i) Maize meal	... ...	1 part
Sorghum meal	... ...	1 part
Coco-nut cake	... ...	1 part
Fish meal	... ...	10 per cent

(ii) The above with 1 part of bran added.

Conditions in outlying districts will have to be studied and rations planned accordingly.

Breeding.—A good deal of further information is needed with regard to cross-

breeding. It might be useful to try cross-breeding both ways: R.I.R. cock x native hens, good native cock x R.I.R. hens. Great difficulty is experienced in isolating any definite "strain" of native birds. An enlarged collection of native birds, picked out by colour and body characteristics, would be useful for any breeding programme.

The initiation of trap-nesting as a routine in the R.I.R. section of the poultry unit would certainly be a big step forward in the improvement of our own stock. To effect this certain modifications in the design of house would be necessary.

REFERENCES.

Poultry Keeping on the General Farm, Ministry of Agriculture Bulletin No. 8, p. 3.

The Culling of Poultry, Ministry of Agriculture Bulletin No. 59, p. 5.

The Scientific Principles of Poultry Feeding, Ministry of Agriculture Bulletin No. 7.

The Rearing of Chickens, Ministry of Agriculture Bulletin No. 54, p. 15.

Diseases of Poultry, Pearl, Surface and Curtis, pp. 87, 103, 151, 236 and 237.

Some Diseases of Poultry, Ministry of Agriculture Bulletin No. 6, p. 24.

The Official Gazette of the Zanzibar Government, dated 4th May, 1935, p. 167.

Egg Preservation

By M. H. FRENCH, *M.A., Dip. Agric. (Cantab.), Biochemist, Dept. of Veterinary Science and Animal Husbandry, Tanganyika.*

Some time ago the Acting Director of Veterinary Services suggested that if an efficient but cheap egg preservative could be recommended to the natives, then many natives would be able to make enough money to pay their hut tax from the profits on their poultry.

A few trials have been undertaken with the object of determining the best egg preservative that could be made easily by the native at very little cost or trouble. As this question is very important for European housewives throughout East Africa, owing to the seasonal productivity of the native fowls, the following account of the preparation of a simple but good egg preservative is presented.

The mixture which gave the best results at Mpwapwa consists of eight parts of groundnut oil and one part of bees-wax. The mixture is easily prepared by shredding native-produced bees-wax into locally prepared groundnut oil, and warming the two together until all the bees-wax has melted. After being thoroughly stirred the mixture is strained through a cloth into a suitable receptacle and then allowed to cool. It sets to grease possessing a nice consistency.

The eggs are smeared all over with this grease and then put away into a cool place. By means of this mixture eggs have been preserved at Mpwapwa for six months with very good results. Naturally some eggs develop a stale smell and taste during preservation, but this happens with all preservatives. Such eggs are perfectly good for most culinary purposes, though not quite good enough for eating in the boiled or fried state.

With this particular preservative no eggs went bad and very few developed this stale taste in the trials at Mpwapwa.

Prospects for the Production of Tung Oil in East Africa

A Comparison of the Results Attained in the Trials of *Aleurites Fordii* and *A. montana*

This subject was one of those discussed at the Agricultural Research Conference held at Amani in February, 1936. In opening the discussion, Mr. Nowell said that trials of *Aleurites* sp. had been going on in East Africa for several years. The original stimulus came from the British Paint Research Association, who found supplies inadequate for their needs. Attention was at first concentrated on *A. Fordii*, good seed of which was readily obtainable from Florida. A small amount of seed of *A. montana* from China was distributed, but only a low percentage germinated. The memoranda before them [which are printed below] from all five mainland territories showed how widespread the trials had been. On the whole, it appeared that *A. montana* grew without trouble, but *A. Fordii*, where it would grow at all, needed to be treated as an orchard tree. Therefore, under East African conditions, *montana* was much the more likely to survive. It has been grown successfully at Morogoro (1,200 feet) and Sotik (6,000 feet). At Amani it flourished. Two hundred acres were being planted, and there should be seed to spare in 1937.

I.—TUNG OIL IN KENYA.

By COLIN MAHER, *M.A., Dip. Agric. (Cantab.), A.I.C.T.A., Agricultural Officer, Kenya Colony.*

At the instance of the Imperial Institute, seed of *Aleurites montana* was first introduced into Kenya in March, 1922, from Hong Kong, and seed of *Aleurites Fordii* from Hankow, China, in July of that year. It is proposed to deal chiefly with *Aleurites Fordii* in this paper, since very little seed of *Aleurites montana* has been planted in the Colony.

The original *Aleurites Fordii* seeds were sown at Nairobi, at an altitude of 5,500 feet, in August, 1922; in May, 1924, the resulting trees were reported by the Conservator of Forests to be from three feet to five feet high. The germination of the early samples of seed was usually poor.

In 1926 the trees at Nairobi were from 5 feet to 7 feet high, while others remained stunted at about 18 inches. The average rainfall of Nairboi is about 37 inches, but in 1925 only 22 inches fell.

The trees were attacked by *Aspidiotus* scale, which was controlled by spraying. Two of the trees fruited in 1927, and a sample of seed was sent to the Imperial Institute for analysis. The report on the sample stated that the results of the analysis agreed closely with those obtained from the oil prepared at the Imperial Institute from the original Chinese seeds and from the oil prepared in China. The seeds produced in Kenya from seed of Chinese origin gave a similar or slightly higher yield of oil of the same character as that derived from the Chinese seed.

At a meeting held towards the end of 1927 the Imperial Institute Advisory Committee considered the possibility of extending the cultivation of tung oil trees within the Empire. East Africa was particularly mentioned, in view of the favourable report which had been made on the seeds grown in Nairobi. A further sample of 15 lb. of *Aleurites Fordii* seed was obtained by the Economic Botanist,

Royal Botanic Gardens, Kew, and forwarded to the Conservator of Forests, Nairobi, in February, 1928; 20 lb. of seed from Florida was sent in January, 1927, and 20 lb. in April. During the next two years considerable amounts of tung oil seed were distributed to farmers by the Forest Department, while several farmers imported seed themselves. Interest in the crop was further stimulated in the Colony by the publication, in June, 1930, by the Empire Marketing Board of the bulletin entitled "The Production of Tung Oil in the Empire."

Two small lots of seed were forwarded to the Imperial Institute from Nairobi in September, 1932. These consisted of seed collected in June and July, 1931, and in June and July, 1932. The report of the analysis, submitted in March, 1933, by Dr. L. A. Jordan, Director of the Research Association of British Paint, Colour and Varnish Manufacturers, was as follows:—

"The two samples were representative of the 1931 and 1932 crops grown at Nairobi, Kenya. The nuts arrived in a clean, dry condition, free from insects and pests. The physical examination gave the following results:—

	1931	1932
	Gms.	*Gms.*
Average weight of nuts ..	2·80	2·93
Nut consists of—	*Per cent*	*Per cent*
Shell	41·2	37·5
Kernel	58·8	62·5
Moisture	6·3	6·4
Oil (solvent-extracted P.E. 60–80)	35·3	36·3
Oil, expressed on dry decorticated kernel ..	67·2	64·7

"The above figures would appear to accord with the average values observed for the species. Oil was expressed in the laboratory hydraulic press, and gave the following results on examination:—

	1931	1932
Colour (Lovibond 10 mm.)		
Red	0·30	0·36
Yellow	1·0	1·4
Refractive Index n_D 25°C.	1·5181	1·5181
Density (25°C.)	0·9361	0·9358
Heat Test	12¼ mins	12¼ mins
Acid Value	0·6	0·4
Iodine Value	167·7	168·0
Saponification Value ..	192·6	194·4

"The gel obtained in the heat test was of satisfactory texture.

"The two oils appear to be of satisfactory quality, with very little difference between them. The slightly higher acidity of the 1931 oil may be ascribed to the storage of the fruit, though the difference in colour runs counter to expectation on this basis."

Questionnaires were issued by the Forest Department to growers of tung oil in 1933 and 1934. In addition to farm trials, a few tung oil trees were tried at all Forest Stations.

The Department of Agriculture took over from the Forest Department the work on tung oil towards the end of 1935. Questionnaires were returned to the Forest Department in 1934 by some seventy growers of tung oil trees in various parts of the Colony. The Department of Agriculture sent out questionnaires to fifty-two of the growers whose previous reports had been amongst the more promising, and to eight other growers in the Trans Nzoia who had not received questionnaires previously from the Forest Department. Replies were received from forty-five growers, or 75 per cent; this response must be considered as very satisfactory.

The information given in this paper as to results of trials in Kenya is largely obtained from these questionnaires, together with reports from various Forest Stations. Scrutiny of the questionnaires reveals the fact that there are now about

500 or 600 acres of tung oil trees cultivated in Kenya Colony; of this acreage, about 400 acres are in the Trans Nzoia district. The largest plantation in the Colony is at Longleat Estate, Kitale, where there are about 100 acres.

Climate.

It appears that the most suitable districts for tung oil (*Aleurites Fordii*) in Kenya are at altitudes of about 6,000 feet with a rainfall of 40 to 50 inches; at altitudes higher than about 6,500 feet the trees usually make very poor growth; when the average rainfall is below 40 inches the trees tend to die out during the dry season.

Altitudes of less than 5,500 feet seem particularly unsuited to the crop, while districts such as Kaimosi, where the rainfall amounts to 60 or 70 inches or more, are also unfavourable for the growth of tung oil trees.

Farmers in several districts complain of defoliation of the trees during the rains. Growth is best in the dry season in districts where the rainfall is heavy enough during the rainy season for some reserves of moisture to be accumulated in the soil; one farmer at Kitale reports that his trees grew two to three feet during the 1934 dry season; growth ceased during the 1935 rains, and commenced again with their cessation.

It is curious that a very high rainfall seems prejudicial to the success of tung oil in Kenya, whereas in the Southern Mississippi it is said that "climatic conditions are apparently good for the growing of tung oil trees, the precipitation being about 57 inches per year" (*Tung Oil Culture,* by Henry A. Gardner, January, 1935). In Burma also, the tree is grown under a rainfall of 69 inches per annum.

Soils.

Little information is available about the suitability or otherwise of the various soil types of Kenya. Poor soils with a hard murram pan give bad results. Black cotton soils also appear to be unsuitable, though in this instance it may be the climate which is at fault. The plantations in the Trans Nzoia are chiefly planted on red sandy loams derived from gneisses and schists of the Basement Complex. The trees planted on the richer chocolate volcanic loams of Mount Elgon and Kiambu did not make better growth than the trees on the poorer soils.

Rate of Growth.

All growers remark upon the extreme variability in the growth of the tung trees. One farmer in the Trans Nzoia, who planted the seed at stake, states that his trees, which are three and a half years old, vary in height from one foot to nine feet.

Many farmers observed that trees that are left in the nursery make far better growth than the trees that are transplanted; in one instance, a tree is recorded to have grown ten feet during one year in the nursery. It is noteworthy, however, that the growth of trees on a twelve-acre plantation which were planted at stake seems little if any better than that of transplanted trees. Probably the superiority of trees that have been left in situ in the nursery is explained by the more sheltered position, the better soil, and perhaps access to water during the dry season.

The oldest trees in the Arboretum at Nairobi are now thirteen years old, and vary between 6 feet and 20 feet high. Some trees six years old are about 11 feet high. While some trees are looking very well, others have died back to a greater or less degree. This may be the

effect of a succession of dry years, but more probably is due, at least in part, to disease; since dead and thriving main branches can be seen on the same tree. Some of these trees fruit fairly regularly, but normally they have only a poor crop. Incidentally, complaints have been received from several farmers in the Colony, especially from near Nairobi in somewhat dry districts, of the periodic dying back of the branches of their tung trees.

Trees in the Colony in general vary between two years and six years old. The growth rate is extremely slow as a rule, and averages only about a foot in height per year, the average yearly increase ranging between 9 inches and 18 inches. Apart from the trees in the Arboretum at Nairobi, some of the oldest trees are some in Songhor, which are seven and a half years old; these are growing at an altitude of 6,200 feet, the average rainfall being 58 inches. The owner states that these trees are now 10 feet high, and have borne a few nuts; although the trees are very healthy, the yield is said to be poor.

One of the more hopeful reports is from the Assistant Conservator of Forests at Muringato, Nyeri (6,000 feet, rainfall 37 inches), who states in his annual report for 1934 that tung trees planted in 1929 average 8 feet 3½ inches, the tallest tree being 16 feet 6 inches. He adds that the trees looked healthy and carried a fair crop of fruit during the year. The tallest trees at Longleat Estate, Kitale, are 9 feet high with a spread of 7 feet. These were planted at stake in 1931. The average height is about 5 feet 6 inches. Flowers have hitherto been removed, but it is intended to allow the trees to fruit from now on. Some of the trees planted at stake in 1933 on a plantation near Kitale were some 8 feet high at the end of 1935 when they were only two and a half years old. These trees have been given more attention than has been given to trees on most plantations in Kenya.

It has already been mentioned that in some districts it is complained that the trees suffer from excessive defoliation, especially in the rains, outside the periodic resting period which must occur if the trees are to make normal growth. It seems just possible that this defect sometimes may be due to the physiological condition known in the United States of America as "bronzing". This disease has been found to be due to a zinc deficiency in the soil, and can be remedied by an application of zinc sulphate to the soil or as a spray. In support of this hypothesis, as regards Kenya tung trees, is the fact that leaf diseases are said often to be rife during heavy rains when leaching out of minor elements would be most intense. It is intended to test this hypothesis by experiment.

Cultivation.

It must be admitted that the trials of *Aleurites Fordii* in Kenya have not erred, as a rule, on the side of pampering the trees. In fact, the method of cultivation adopted have been in sharp contradistinction to those in tung oil growing districts of the United States of America. In that country, for example, trees planted on poor soil have been planted in large holes, in which was placed 40 lb. of "muck" which had been dug from old lake beds. Trees planted with this aid are said to have made a growth of six to eight feet in five months. Only ten Kenya farmers, or 22 per cent of the forty-five who returned questionnaires in 1935, stated that they had applied *boma* manure to the trees; one of these stated that the application of cow manure and mulching gave a good response. One

farmer applied a dressing of a quarter of a ton per acre of bone meal.

In America, it is observed that "the importance of growing cover crops among tung oil trees cannot be overemphasized". This method of soil improvement has been almost entirely neglected in tung tree plantations in Kenya, where, however, physical or physiological damage may sometimes have been caused by the practice of intercropping the trees with maize. In many plantations the land has been allowed to become overrun with "couch". Only two growers reported having green-manured their tung oil plantations, and three growers reported that they mulched the trees, the latter farmers including a grower who mulches the green manure crops round the roots of the trees. In many instances damage has probably been caused by deep cultivation to the shallow root system of the tung trees on plantations in Kenya.

General Conclusions.

It appears from the results of the trials made to date that *Aleurites Fordii* is not generally suited to Kenya Colony. The reason for this is not clear, since the climate would seem to be somewhat similar —with the exception that snow and frost are absent—to the parts of China in which the tree is grown; possibly, the trees suffer from the shortness of the hours of daylight in Kenya.

No figures are yet available for yields of nuts from plantations of any size that are at least five years old. Yields from a few scattered trees of bearing age are not very promising, but these older trees are chiefly in districts that are not likely to be suitable for the tree.

The general standard of the culture of the tung trees in Kenya seems to have been low, and ten acres of tung oil are to be established at Kitale by the Department of Agriculture in order to determine whether more intensive and careful culture may give better results. One grower in the Kitale district reports that part of his plantation has grown much better than the rest; this circumstance will be investigated in the hope of discovering some clue as to possible relationships of the composition of the soil to the growth rate. It seems possible, however, that the superior growth of these trees—which are about 8 feet high two and a half years after planting out—may be ascribed to the protection afforded to the tung oil by a belt of gum trees.

Reference has been made to the marked variation in growth of tung trees in the plantations in Kenya Colony. It is believed that this is due to the genetical variation which has been observed in other countries. Attempts will be made later to graft scions of the more vigorous trees on to root-stocks of the other trees or on to stocks of other species. A farmer in the Trans Nzoia notes that while the aerial growth of his tung trees is poor, the root systems seem to be well developed.

On the results of experimental plantations that have been made in Kenya Colony up to the present time no further plantings of *Aleurites Fordii* could be recommended; the plantations in the Trans Nzoia may, however, cause these words to be modified during the next two or three years.

It is considered that extended trials should be made of *Aleurites montana, Aleurites moluccana* (or *triloba*) and, perhaps, *Aleurites cordata.*

Very few trials have been made of *A. montana,* since it was thought originally that the climate of Kenya was likely to be much more suited to *Aleurites Fordii.* However, the Assistant Conservator of Forests, Eldoret, reported in

1934 that he had twenty trees of *Aleurites montana* in the Kisfim glade in Kakamega Forest, planted in 1932, which were 12 feet high and in a flourishing condition. This station is at an altitude of 5,200 feet, and has an average annual rainfall of 70 inches.

There are three or four trees of *A. montana* in the Arboretum at Nairobi. Despite the fact that the rainfall at Nairobi is too light for this species, these trees at present look quite well. The best tree is 12 feet high, and has a spread of about 10 feet. These trees are five years old from seed, and fruited for the first time in 1935.

A very hopeful report was received from Sotik at the end of 1935 with regard to several acres of *Aleurites montana* trees, seed and plants of which were planted in 1932, so that the trees are now three and a half years old. The trees were planted at an altitude of about 5,700 feet, and the average annual rainfall is probably about 54 inches. It is stated that "We found that there was no comparison between the *Aleurites montana* and *Aleurites Fordii*. The *montana* has flowered prolifically, and the growth is both even and quick, some of the trees being 17 feet to 20 feet high, whilst the *Fordii* are slow, stunted and uneven."

The quality of *montana* oil is nearly equal to that of *Fordii*.

A tree of *Aleurites moluccana* (the "Candlenut" tree), planted probably in 1927 at the Scott Agricultural Laboratories, Nairobi, has made vigorous growth at an altitude of 5,700 feet, with an average annual rainfall of 40 inches over the last nine years. This tree was about 18 feet high at the end of 1935, with a spread of 31 feet. It fruits fairly prolifically.

A farmer at Fort Ternan writes that he has a Candlenut tree which is 30 feet high and came into bearing within six years. This is at an altitude of about 4,900 feet, with an average yearly rainfall of 60 inches. The oil obtainable from the nuts of this tree is said to be inferior to linseed oil for varnishes and similar uses. However, the tree, in view of its healthy and strong growth, might be further tried as a stock on which to graft scions of the more valuable species of *Aleurites*, though it is reported from Amani that attempts made there have failed.

There are also several Candlenut trees in the Arboretum at Nairobi. They are about eight years old, and have a height of some 30 feet. They fruit regularly, but not freely. This tree is very pleasing in appearance, and might be of value as a shade tree for cacao; although it might prove to give too dense a shade, it is certainly worth experimenting with as a shade tree for coffee in Kenya.

It is not believed that *Aleurites cordata* Steud, the source of Japanese wood oil, has been grown in Kenya. Like that of the Candlenut, the oil does not possess the property of gelation, to which tung oil owes its value.

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Acknowledgements are made to the Conservator of Forests, Nairobi, for his kindness in giving the writer access to the files of the Forest Department dealing with the work on tung oil, and for being very helpful in discussing with him the subject of this crop; the thanks of the writer are also expressed to those farmers who kindly completed and returned the questionnaires.

II.—TUNG OIL IN UGANDA.

Note by A. S. THOMAS, *M.Sc., A.I.C.T.A., Assistant Botanist, Uganda.*

The following is a report on the results to date of trials of *Aleurites Fordii* and *A. montana*:—

The first small consignment of seed was received in Uganda from Amani in 1929, and was sown at Kampala; nine plants of *Aleurites Fordii* and one plant of *Aleurites montana* resulted, and were planted out on the Kampala plantation in 1930. At first the plants grew well, and reached a height of about 4 feet in two years, but subsequently they died back almost to the base, from which short shoots arose, and their condition now is very much worse than it was in 1932. There is a great contrast between such plants and the young trees to be seen in the Arboretum at Nairobi.

The main introduction of seed of *Aleurites Fordii* was in 1931, when a larger quantity of seed was received from Kenya and was sown at Bukalasa and Serere. The germination of the seed was poor. From the 174 seeds sent to Serere only 26 plants were raised; presumably about the same amount of seed was sent to Bukalasa, and about 25 plants were raised there. The present size of the trees at Serere is small, the best are only 2 feet high; at Bukalasa, as at Kampala, these trees grew quite well at first; in 1933 they were reported to be 2 feet high, but their subsequent growth has been poor, and they average about 2½ feet in height at present.

A batch of seed of *Aleurites montana* from Kew was sown at Serere in June, 1933, and the seedlings planted out in July, 1933, but these plants have also grown very badly; there are 34 alive at the present time.

The plants have been tried on different soils: At Kampala they are in heavy clay; at Serere on a stony hillside, and at Bukalasa in a pocket of good soil on the hillside. Yet at all places they have grown very badly, and it would seem to be proved that the climate at an altitude of about 4,000 feet is definitely unsuitable for these species.

The more tropical species, *Aleurites triloba*, has been planted extensively in Uganda as a quick growing tree. It is possible that it might be of use as a source of tung oil, for some of the old trees at Entebbe produce a quantity of fruit. (I was under the impression that *Aleurites triloba* and *A. montana* were distinct species, but find that most authorities consider them as synonymous.)

III.—TUNG OIL IN TANGANYIKA.

Note by C. J. MCGREGOR, *Dip. Agric., Agricultural Officer, Tanganyika Territory.*

An article on tung oil by C. J. McGregor, Agricultural Officer, Tanganyika Territory, based on a visit made by him in 1934 to Florida and Southern Georgia, U.S.A., was published in the *East African Agricultural Journal*, Vol. I, No. 2, p. 127. In this he states, "Tung oil trees in the Southern Highlands have in the past proved unsuccessful. In spite of this, however, there are encouraging indications. I am convinced that the failures in the past were largely due to the fact that the trees were handled as forest trees. It may be possible to do that in the richer stretches to the north of the Territory, but in this area it is certain that if the trees are to succeed they must be treated as delicate, heavy-yielding fruit trees, for that is undoubtedly what they are." A brief report on tung oil in the Southern Highlands is given below.

Distributions of seed of both *Fordii* and *montana* were made during the period 1927-32 to non-native planters

only, throughout the Northern and Tanga Provinces and in the Western Province. As far as is known, the trials failed in all but the latter areas. It is considered that in some parts this may have been due to faulty methods, especially in transferring the plants from nursery to field, but on the whole the failure was so wide as to indicate that the soil conditions at least were unsuitable.

In the Western Province conditions appear to be more favourable. Near Uvinza there is one plantation of 50 acres or so, planted in 1932, which appears to be in good condition. The trees are 5 feet to 7 feet in height; some are 8 feet and more. They are healthy, and are now flowering fairly profusely and setting fruits.

It is considered that in the Western Province and also the Southern Highlands results are sufficiently promising as to warrant extension of trials of a rairly wide scale.

Note on Tung Oil in the Iringa Province.

In 1927-28 seed of *Aleurites Fordii* was distributed in Mufindi, Dabaga, Nguruhe, Ifunda, and Lupembe.

Mufindi.—There are a few trees still growing in the tea area. They are about six feet high at six to seven years old, and have an odd flower or two this year.

Dabaga.—No trees living.

Nguruhe.—I have seen two trees about 8 feet high at Egger's farm, also in an unsatisfactory state.

Lupembe.—Of the original seed no trees are living.

Mr. Hayward commenced experimenting with both varieties in 1920 near Njombe. He planted at stake, but lost most of the first lot. He has continued planting with, in my opinion, little success under his "forest tree" methods. The biggest trees I saw on his farm are only a few feet high at several years old.

From Mr. Hayward's seed of *Fordii* a few trees were planted by Mr. Reed at Lupembe in 1931. These trees showed no promise, only attaining a height of 6 feet in four years, and the few flowers dropped. In 1934 the trees were heavily manured, after which they grew a further 4 feet and set flowers and fruit.

In 1933 *montana* seed was obtained here at Iheme. Only four seeds germinated, and the trees were set out in January, 1934. They went dormant in 1934 and again this year, but have only grown a foot or two.

From the foregoing it will be seen that tung oil has never had a chance here. At the outset the trees were treated as they are supposed to be in China, i.e. like a forest tree. Under these conditions they are very slow growing indeed, and show no promise planted on odd patches of stony land, in the teeth of strong winds, in swamps, and overgrown with weeds. The only promising trees are those at Reed's farm (now an R.C. Mission), and these only showed promise after heavy manuring.

Thirty pounds of seed have now been planted at Iheme, at stake and in the nursery. The nursery germination is over 90 per cent. The seed at stake shows poor germination. It is thought that the better germination in the nursery is due to the judicious use of grass-mat coverings.

(Supplementing the information given in the above note, Mr. Wakefield told the Conference that one planting of *A. Fordii* in Tanganyika Territory had done well. Fifty acres had been put in 120 miles east of Kigoma in 1932. The original method of planting was excellent, in pits 3 ft. x 4 ft., with plenty of

rich refuse. Although the plantation had received practically no attention since, the trees were now 8 to 10 feet high, flowering profusely and setting fruit. The Tanganyika Department had ordered supplies of seed from China for further trials, and he would report in due course on its condition.)

IV.—TUNG OIL AT AMANI.

Note by Amani Agricultural Research Station.

Seed of *A. Fordii* was received from the Paint Research Association in 1928. Plants to the number of 4,800 were raised in the nurseries and distributed in Tanganyika, Kenya and Zanzibar. Seed sent in the following year from Kew was transmitted to Uganda, Nyasaland, and Northern Rhodesia.

Trial plots at elevations from 1,500 to 3,500 feet at Amani have shown no promise. The plants have continued to exist, but with rare exceptions have made no appreciable growth. One or two have produced a few flowers. Similar reports were received from a range of sites from Zanzibar to 4,500 feet on Kilimanjaro.

Seed of *A. montana* was included in the Kew consignment in 1929. It was from China, and in poor condition. A few plants were grown at Amani, and two left in the seedbed were 10 to 12 feet high and flowering abundantly in three years (November, 1932). Others which were transplanted have also developed well. The flowers seem nearly or wholly dioecious, and our first examples being scattered hand pollination was resorted to. We do not yet know how efficient natural pollination will be. The seed obtained has been planted year by year, and the plants are doing well.

Dr. Jordan, Director of the Paint Research Association, has recently announced that *montana* oil will now be accepted by the trade in England. Its value is 95 per cent of that from *Fordii*.

V.—TUNG OIL IN NYASALAND.

Note by the Department of Agriculture, Nyasaland.

(*a*) *Aleurites montana.*—Two acres of *montana* were planted out on Zomba Experimental Station in 1932. Some of the trees bore fruit in 1934. Records of time of flowering, type of inflorescence, and fruit, and weight of fruit are being kept. In 1935 a numbered tree gave as much as 33 lb. of fruit.

It is apparent from other trials on lateritic and red loam soils under an average rainfall of 40 to 55 inches that *montana* holds out hope of success as an economic crop. European interest is growing yearly, and efforts are being made to develop the growing of *montana* as a village industry. It should appeal to native growers as a crop requiring little attention, and it is easy to harvest.

(*b*) *Aleurites Fordii.*—This species has been grown at higher elevations since 1930, but the trials are less successful than those of *montana*. The yields have been poor on the whole, and the trees have been susceptible to scale-insect attack and leaf diseases in parts.

The oils of both *montana* and *Fordii* have received good reports from the Imperial Institute.

VI.—TUNG OIL IN NORTHERN RHODESIA.

Note by the Department of Agriculture, Northern Rhodesia.

Aleurites Fordii.

(*a*) *At Abercorn*, altitude 5,400 feet.—Average rainfall 45 inches; September to May. *A. Fordii* was planted five years

ago, 1½ acres without irrigation, and 1 acre irrigated. Germination and growth in the first season were good. Thereafter the unirrigated trees died back almost to the ground level every dry season. The irrigated plot was very little better, and the tallest tree has only attained a height of 5 feet.

(*b*) *At Mazabuka*, altitude 3,400 feet. —Average rainfall 30 inches; November to April. A plot planted over three years ago has proved a complete failure. The trees are barely 2 feet high, and die back every year.

Aleurites montana.

Has grown satisfactorily at Mazabuka. In their fourth year the trees have reached an average height of about 7 feet and are flowering profusely. Germination was poor.

Sand for Cement Concrete

Probably more Portland cement is wasted through the use of unsuitable and dirty sand for making cement concrete than in any other way.

Some farmers get good results with much leaner mixtures for concrete than can other farmers. Thus Farmer Jones gets a good cement concrete with a mixture of 1 to 4 to 8, i.e. one part Portland cement to 4 parts sand to 8 parts broken stone, whereas Farmer van der Merwe, whose farm is in another district, on using that mixture, finds it gives him nothing but trouble. He tries richer mixtures, and ultimately finds that he cannot get a satisfactory cement concrete with a mixture leaner than 1 : 2½ : 5. What is the reason for this seeming inconsistency? In all probability it lies in the sand. Farmer Jones's sand happens to be a naturally "well-graded" one, whereas Farmer van der Merwe's is not. A well-graded sand is one that contains all sizes of grains, from that which will just pass through a quarter-inch mesh down to very small grains.

A sand which consists only of coarse grains will require an unduly large proportion of cement to fill up the spaces or voids between the grains of sand.

On the other hand, in the case of a well-graded sand, speaking in a very general way, the second size of grains tends to fill the voids between the largest grains, while the third size tends to fill the voids between grains of the second size, and so on down the scale, and the cement then has to fill only the remaining voids (in addition to coating each grain of sand).

Farmer Jones has a better-graded sand available on his farm than has Farmer van der Merwe, and hence can use leaner mixtures.

In conclusion, it may be stated that very fine sand requires a large proportion of cement, because the fine sand possesses an excessive amount of surface to be coated (by the cement). To get good concrete or mortar with fine sand, so much cement has to be used that it becomes uneconomical.

People will not add sufficient cement, hence concrete made with fine sand is usually unsatisfactory, and it is better to avoid the use of such sand. This is one reason why the extremely finely ground material of the mine dumps of the Witwatersrand has never been used to any extent for cement concrete.—(Dr. W. S. H. Cleghorne, Lecturer in Engineering, Grootfontein School of Agriculture, Middelburg, C.P.: Press Service, Department of Agriculture, Union of South Africa, 17-3-36.)

Derris Root

By C. B. GARNETT, *M.A., Agricultural Officer, Tanganyika Territory.*

Considerable interest in several parts of the Empire is at present being shown in the production of derris or tuba root (the word "tuba" is Malayan and is applied to a number of poisonous plants), the principal use of which is as an insecticide. It is one of the essential ingredients of several proprietary insecticides, used both as dusts and sprays, and though it appears to be less effective as a stomach poison it is an efficient contact insecticide against certain classes of insect. Practically all the derris of commerce is derived from the Malayan Archipelago.

There are nearly fifty species of derris known to exist, but only two of these have come under any general cultivation, and as these differ in toxic content, and therefore in value, a few botanical notes may be helpful.

(*a*) *Derris elliptica.*—This plant adopts a creeping habit, often forming a dense cover, with the stems frequently rooting at the nodes. Leaflets usually 7 or 9, not overlapping, usually obovate or obovate-oblong. Tips with a definite prolonged narrow point. Upper surface without hairs or with very sparse whitish hairs. Lower surface with whitish bloom and a sparse covering of pale reddish hairs. Petiole, rachis and petiolules with a few whitish or pale red hairs, but sometimes hairless. The backs of petiole and rachis without hair. (There are varieties of the species which show inter-variation in toxic content. Planters are advised therefore to seek expert advice before any planting material is ordered.)

(*b*) *Derris malaccensis.*—The botanical data of this species are very similar to those of *D. elliptica,* but it is immediately identified from the latter by its erect habit of growth. It is a shrub-like plant, not forming a cover, and with the stems not trailing on the ground.

CULTIVATION.

Derris is easily propagated by stem cuttings. The cuttings are of mature wood, 15 to 20 inches long, and are usually planted in nursery beds, lightly shaded. They may be expected to root in about three weeks, and at six weeks are sufficiently developed for transplanting into the field. The cuttings may be planted direct into the field, but if this is done the leaves should be removed to prevent excessive transpiration, and any sets which fail to root should be immediately replaced, so that eventually a regular stand is obtained.

Light soils of a sandy nature should be selected where possible, and the land should be flat or only gently undulating, owing to the danger of erosion. Heavy soils should be avoided owing to the difficulty of harvesting the roots under such conditions.

Derris may be planted as a pure crop or as a catch crop with more permanent cultivations. In the former case the plants are 3 feet apart, giving 4,840 plants to the acre. In the latter, the distance will vary according to the crop with which the derris is being interplanted.

HARVESTING.

It is most important that harvesting should take place at the correct stage of maturity, because the toxicity of the roots varies with their age. Experiments in Malaya have shown that, taking into account both the yield of the root and its toxic content, the optimum age for harvesting is when the plant is about 24 months old.

At the time of harvesting the leaves and stems are discarded, as they have no value. The roots are then lifted, cleaned of soil (with water, if necessary), and allowed to dry in the sun. Care should be taken to harvest the smaller roots, since it has been found that the percentage of toxic principle contained in them is higher than in the larger roots. A flue-heated drying chamber may be employed on estates producing derris on a large scale.

When dry, the roots should be baled as quickly as possible, since they are liable to attacks of boring beetles. Sometimes, in order to reduce the bulk of material for ocean shipment, the dried roots are chopped and ground into a coarse powder and baled or packed in tins.

The yield of air-dried roots is approximately 45 per cent of the weight of fresh roots. The moisture content of the air-dried product is about 10 per cent. Under favourable conditions the yield of air-dried root is approximately half a ton per acre.

Pests and Diseases.

Derris is liable to considerable injury by numerous insects, both in the field, and, paradoxical as it may seem, in storage.

The most serious field pest reported from Malay is a beetle, *Craniotectus corbetti* Laboiss., which attacks the leaves, but which readily succumbs to a pyrethrum spray.

Several species of beetles attack the root in the dry stage. The eggs are laid in cracks and irregularities on the outside of the root, and the larvæ, on hatching, bore into the root and reduce it to powder. Prevention is best secured either by packing the roots immediately they are dry or by the erection of an insect-proof store. When once the roots have become infested the beetles may be eliminated either by exposure to strong sunshine or heat, or by extended fumigation with carbon bisulphide.

No serious fungus diseases have yet been recorded.

Preparation and Uses.

Literature regarding the methods of extraction of the toxic principles contained in derris and of their subsequent utilization is still very scanty, but much research is being carried out, and further information is becoming rapidly available. It is known that derris contains four closely related toxic compounds, viz. rotenone, deguelin, tephrosin, and toxicarol. Of these, rotenone was for some time regarded as being the most important, and valuation of derris was based on rotenone content. It has been shown recently, however, that there are other additional compounds which are effective, and which may be obtained by making an ether extract, and it is advisable therefore that valuations should be fixed on total ether extract rather than on rotenone content.

Analysis of the two main species under cultivation gives the following figures:

	Rotenone Content.	Ether Extract.
D. elliptica	7–10%	25%
D. malaccensis ...	1%	20–25%

Other solvents besides ether may be employed, but it would seem desirable that the sale of derris in whatever form should be regulated by analysis, in view of the highly variable percentage of toxins in the different varieties of roots.

There is still much to be learnt regarding both the effectiveness and the limitations of derris compounds, and there is as yet no classification of pests on the basis of their vulnerability to derris.

More precise information is rapidly being obtained, but in the meantime it is not possible to say with any accuracy except in certain proven cases against which species of insects it is thoroughly efficient.

It is established, for instance, that derris is a reliable fish poison. Of negative interest to East African coffee planters are trials conducted with sprays against *Antestia* at Amani, when no effect was apparent. An aqueous solution of rotenone has been found to be effective against thrips, white-fly larvæ, leaf hoppers, larvæ of beetles and certain caterpillars, whilst the dust form has been successfully employed against chicken lice, roaches and cabbage worms. Derris, used either as a dry powder or made up into a wash, has given satisfactory results in eradicating warble flies and lice on the backs of animals, particularly cattle, in England. In the Philippines, derris is reported as being highly effective against mosquito larvæ in concentration of 3 : 1000.

It is practically non-toxic to man or domestic animals.

Market prices are subject to considerable fluctuation, but as an indication it may be stated that roots at the port of shipment are at present valued on analysis at between 50 and 80 cents of a shilling per lb.

REFERENCES.

Adriano, F. T.—Philippine Journal of Agriculture, Vol. 5, No. 1.

Adriano, F.T., Oliveros, S. B., Tabije, O., Crisostomo, F.—Philippine Journal of Agriculture, Vol. 5, No. 4.

Davies, W. M., and Jones, E.—Journal of Ministry of Agriculture, Vol. XXXIX, No. 9.

Editorial.—East African Agricultural Journal, Vol. I, No. 1.

Grist, D. H.—Malayan Agricultural Journal, Vol. XXIII, No. 10.

Henderson, M. R.—Malayan Agricultural Journal, Vol. XXII, No. 3.

Worsley, R. R.—Amani 4th Annual Report.

Worsley, R. R.—Amani 7th Annual Report.

Worsley, R. R.—East African Agricultural Journal, Vol. 1, No. 1.

The Sisal Weevil

By W. VICTOR HARRIS, *M.Sc., F.R.E.S., F.Z.S., Asst. Entomologist, Department of Agriculture, Tanganyika Territory.*

The cultivation of sisal (*Agave sisalana*) in East Africa began in 1893, when a consignment of bulbils from Florida was landed at Tanga. These were planted at Kikogwe, a plantation immediately to the south of the estuary of the Pangani River. A later importation, believed to have come from the Bahamas, is recorded about 1900-01 (Kew Bulletin, 1934). Plantings of Mauritius hemp (*Furcraea gigantea*) were made about the same time, but were soon discontinued in favour of sisal. Both *Agave* and *Furcraea* are plants native to Central America.

The industry developed steadily, particularly in the Tanga area. Later, the development spread south to Dar es Salaam and for some distance inland along the Central Railway, and also along the coast at Lindi. The importance of this crop in Tanganyika is indicated by the exports of fibre in 1935, amounting to 82,676 tons, valued at £1,134,732.

The Agaves as a group have few insect pests. In 1914, Morstatt (1921) found holes in the leaves and central shoots of mature sisal in the Pangani and Tanga districts. This was shown to be the work of a weevil, subsequently identified as *Scyphophorus acupunctatus* Gyll. Bulbils and suckers, newly planted out, were also found to be dying off from the same cause. The late Mr. A. H. Ritchie (1923) records that on his arrival in Tanganyika in 1921 he found that the weevil had "bred uncontrolled in neglected ex-enemy properties in the senescent or decaying poled material" and was "apparently confined to the coast from the Kenya border to Mwera, south of Pangani". In 1923, there was a small, distinctly localized outbreak at Korogwe, fifty miles inland. The weevil was very bad in the coastal plantations near Tanga during October and November, 1924. Since 1932 the weevil has come into prominence again.

This present account is written in amplification of Entomological Circular No. 3 of 1934, and embodies the results of our observations made to date.

NATURE OF DAMAGE.

The most obvious symptom of weevil attack is the presence in the leaves of holes about 1 cm. in diameter. Where these are observed on a more or less developed leaf it will be found that six or seven leaves on the same plant are similarly affected, and that the younger the leaf the nearer the hole is to the tip. This would indicate the habit of the weevil of boring into the heart of the plant where the young leaves are still unfolded (Fig. 1). Single leaves already released from the heart-whorl are not attacked. Though leaves exhibit this perforation at the time of their cut, it will be understood that the injury has been done a long time previously. Sisal plants are generally attacked in this manner when under two years old, but as the rate of sisal growth varies in different localities this period may be longer. When a sisal plant over three feet in height is found with the unopened centre leaves perforated, some predisposing cause should be looked for, such as disease, root injury, waterlogging, etc.

When a young sisal plant is healthy and vigorous there is not likely to be any further development of the injury beyond the perforation of the six or seven early leaves, and subsequent leaf production is

not affected. In cases where a plant is not growing vigorously, as, for instance, a newly planted out sucker which has not yet produced an adequate root system, a plant which has been injured during

FIG. 1
Weevil injury to three year old sisal. Rotting has started in heart by infection through holes made by adult weevils. Outer leaves with shot-holes.

weeding, or a sucker in an old field overshadowed by the stump of the old parent plant, then the reaction of the leaf tissue surrounding the boring is not sufficiently active to prevent the entrance of rot-causing organisms. The rot spreads down the central shoot, which becomes red and soft and the plant dies. Large suckers used for planting are more liable to serious injury than small suckers or bulbils.

Small suckers and bulbils are attacked in a less obvious manner by the weevil penetrating between the bases of the outer leaves into the "onion". This may occur in nurseries adjacent to heavily infested areas. In the case of suckers, the weevil may enter the base directly through the soil, being attracted to the cut surface of the base. In assessing weevil injury in newly planted areas, it must be realized that deep planting and injury to the leaf bases, due to carelessness in cutting off the original sucker roots, are primary causes of the death of plants, and that, though the weevil is attracted to them, it is in such cases definitely a secondary pest. Suckers injured during their removal from the parent plant are in the same way unsuitable for planting. Weevil damage in newly planted areas, causing loss of both time and money in replanting, is the most serious feature of weevil attack.

There remains one further type of injury to be discussed; that is, the effect of weevils feeding on large, healthy sisal leaves. Leaves on cutting are found to have areas of brown, dried-out epidermis about eight inches from the butt end (Fig. 2). These patches may be as large as the palm of the hand, and on both the inside and outside of the leaf. Examination of the growing plant shows that the injury is done while the leaves are still more or less part of the heart or central shoot. The weevils work their way down the partially opened leaves as far as they can, and feed on circular patches of epidermis, usually beginning at at the edge of a leaf, so that the injury is later observed on the edge of one leaf and in the middle of the next inner one. If the weevil can work its way in between two closely pressed leaves, it does so, and produces similar dead areas on the inside of the outer leaf. The end of the weevil's

proboscis is furnished with a pair of small mandibles. With these it takes a large number of small bites into the soft outer layers of the sisal leaf, without penetrating into the parenchyma or body of the leaf, in which the fibres lie. The collapse of the injured cell affects those adjacent, with the result that the dead areas coalesce to form a continuous brown patch on the surface. Similarly, this collapse of cells progresses inwards as far as the first layer of fibres, which themselves become discoloured. If there is a great deal of growth in the leaf subsequent to this injury, slight splitting of the substance of the leaf may take place, which induces discoloration deeper into the tissues. On decortication, the fibres appear brown in the vicinity of the injury, owing to the adherence of the dead plant tissue. The actual injury to the fibre is not considerable, though there may be some weakening and consequent increase in tow on brushing. The appearance is somewhat spoilt. The injury is purely mechanical, and in every way similar to that produced by friction with weed growth, suckers or the spines of a neighbouring plant.

FIG. 2

Adult weevils puncture epidermis of outside leaves of heart of healthy sisal plants. This shows up later as dead areas near the base and fibre is seen to be discoloured and weakened on decortication. Similar injury results from scratching by other plants.

As has been stressed already, the nature and severity of weevil injury is closely related to the age and general health of the plant concerned. This is more apparent where the insects are not very numerous and the individual weevil has a wide choice of plants. The scarring of large leaves is an exception, in that it appears to depend solely on the population density of the weevil and not on the health of the plants. It is the weaker plant which is perforated through the central shoot, but weak and strong alike may be scarred. There is, however, a very evident varietal susceptibility to weevil injury. Many people have observed the greater severity of weevil attack on *Agave amaniensis* and *Furcraea gigantea* growing in small plots on a number of plantations, particularly near the coast. At Amani, however, which is from 2,500 to 3,000 feet higher than the sisal plantations, weevil injury to *Agave sisalana* and *A. amaniensis* is negligible, on the ornamental *A. ingens* scarring of mature leaves and some holing of suckers is present, while large plants of *Furcraea gigantea* were disfigured by large irregular holes in all the leaves (Fig. 2). It is evident that had commercial plantings of Mauritius hemp (*Furcraea gigantea*) been continued in this Territory, the sisal weevil would most probably have assumed a greater importance. Ballou (1920), writing of Curaçao in the West

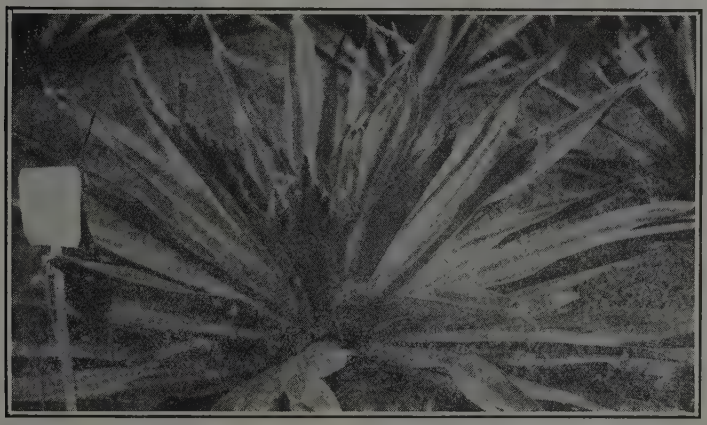

FIG. 3
Effect of sisal weevil on the softer leaves of *Furcraea gigantea*, Mauritius Hemp.

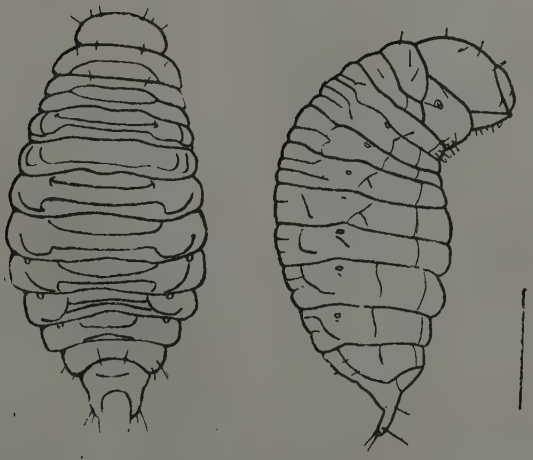

FIG. 4
Larva or grub; × 4.

Indies, states that both larvæ and adult weevils were found in the stem and leaf bases of *Agave frankeera* that had not yet formed a pole; in *A. vivipara* only in the "bull end" of the flower pole; while *A. sisalana* was not attacked at all.

DESCRIPTION OF THE STAGES.

The life of the sisal weevil is made up of four stages: (i) egg, (ii) larva, (iii) pupa and (iv) adult.

The Egg.—The egg is from 1.6 to 1.75 mm. in length, and 0.7 mm. in width. It is a more or less regular ovoid, with only a slight difference in curvature in the two ends. It is creamy-white in colour. The envelope is thin and smooth.

The Larva.—The larva or grub is 1.5 mm. long at the time of hatching. The body is creamy-white; the head is pale yellow, with darker jaws or mandibles. The last segment of the body is drawn out into two small fleshy processes, each of which bears three bristles, two of which stick out straight behind; the third is shorter and points downwards.

The fully grown grub (Fig. 4) reaches a length of from 16 to 20 mm., with a maximum width of 9 mm. The head is 4 mm. wide, chestnut-brown in colour, with dark brown to black mandibles. Two lines of paler colour from the top of the head to the eye form an inverted "V". The head bears a number of short hairs. The body is creamy white, with a yellow polished plate on the first (prothoracic) segment. Legs are absent. The segments of the body are marked by deep folds in the skin. The spiracles are small and inconspicuous. The body is greatest in cross section at the seventh and eighth segments, after which it diminishes rapidly. The last segment is curved upwards, and bears two large fleshy projections, up to 2 mm. long, of a deeper yellow colour than the rest of the body, each bearing three strong hairs. In a few cases it has been observed that the terminal hair is paired. The larvæ of the sisal weevil are readily distinguished from other grubs, such as those of the palm beetles, cockchafers, etc., found in rotting sisal and other plants or in the soil, by the particular shape of the terminal segments of the body.

The Pupa.—The pupa (Fig. 5) is from 15 to 19 mm. long. It is at first pale yellow, but darkens in colour as the black pigment of the developing weevil becomes visible through the skin. The wing cases, legs, snout, etc., can be distinguished in their separate folds of skin closely pressed to the sides and undersurface of the body.

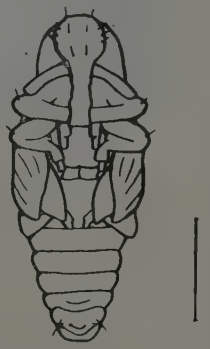

FIG. 5
Pupa or resting stage; × 4.

The Weevil.—The adult weevil (Fig. 6) is dull black in colour. There is considerable variation in size, from 9.5 to 15 mm. in length without the proboscis, which in itself may vary from 3.5 to 5.5 mm. The head is small, being mostly drawn out into a long proboscis, which is typical of the weevils of this group. The eyes are inconspicuous, but large and apparently functional. A pair of 8-jointed antennæ arises from near the base of the proboscis. The prothorax is large, and

though covered with a large number of very fine pits, the general effect is smooth compared with the rest of the insect. It has a row of fine yellow hairs on the anterior border. The elytra or wing cases cover most of the abdomen. They each have nine rows of large pits, which coalesce more or less to form longitudinal furrows, and intermediate rows of finer pits on the ridges thus formed. The

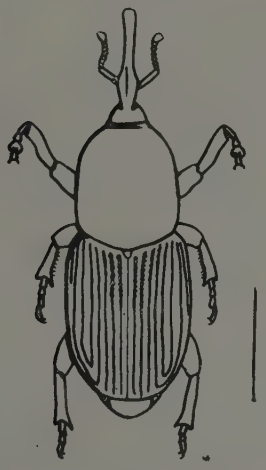

FIG. 6
Adult sisal weevil ; × 4

elytra are not fused but fit together very closely. The wings are large and apparently capable of being used for flight.

The two sexes are very similar externally. There is a tendency for the males to be smaller than the females, but this character cannot be used with any certainty for distinguishing them.

LIFE-HISTORY AND HABITS.

The egg of the sisal weevil is thin-walled and quickly collapses if exposed to low atmospheric humidity. The grub is white and thin-skinned, and is also easily killed if subjected to dry surroundings. Its dislike for the light can easily be demonstrated. Eggs are to be found in the following places: —

1. In the base of young bulbils or suckers, where the injury caused by the boring of the adults causes local rotting. Usually, not more than two grubs develop in a plant.

2. In the hole made by the adult weevil in the central shoot of a larger plant, the egg is inserted directly into the leaf tissues inside the hole, or introduced into the gap between two leaf surfaces. As a general rule only one grub develops under these conditions.

3. If the boring of the central shoot induces rotting and subsequent death of the bud, the weevils penetrate to the solid tissues of the base of the plant and lay numerous eggs there. Similarly, if the central shoot dies from any other injury or disease, the weevils penetrate to the base and oviposit.

4. When a plant commences to pole, weevils are attracted and congregate around the base of the pole. As the pole develops, the leaves and stump lose their firmness to some extent, and the weevils are then able to bore inside. The cutting off of the young pole to prevent loss of fibre in leaves still to be cut, or the development of a soft rot at the butts of the remaining leaves, common in some localities, enables the weevils to penetrate somewhat earlier. As the stumps wither and begin to decompose, the weevils, and in time their grubs, progress further into the interior (Fig. 7).

5. Stumps that have died off in situ, or that have been cut and left on the ground, remain breeding-grounds long after they have lost their green colour.

In short, eggs are to be found either in living tissues weakened by injury or disease, as in newly planted suckers and bulbils and in holes in the central shoot,

or in dead plant material, as in old stumps. The incubation period varies from three to four days.

The larva emerging from an egg laid in a perforated central shoot proceeds to make a small channel by eating out the soft epidermal layers of two closely pressed leaves, and thus moves away from the hole made by the adult itself. The channel increases in diameter with the growth of the grub, and follows an erratic course. Where general infection of the shoot has not taken place, the larva does not appear to wander far from the original hole, but returns later to complete the work of the adult in boring right through the shoot, and pupates in the hole thus made. Larvæ in the base of a young plant or in a larger plant where the heart has died out bore irregular channels through the tissues until their development is complete. The fully developed larva makes a rough cocoon from small pieces of fibre and leaf debris, cemented together lightly on the inside, in which it pupates 28 to 55 days after hatching from the egg.

FIG. 7
Sisal plant, having poled, now makes ideal breeding ground for weevils. Weevils already penetrated base of pole and egg-laying will follow.

The pupa does not feed, but remains immobile in the cocoon for a period of from 19 to 36 days.

The development of the weevil is thus seen to be made up as follows:—

Egg	... ...	3 to 4 days.
Larva	... ...	28 to 55 days.
Pupa	... ...	19 to 36 days.
	Total ...	50 to 95 days.

The incubation period of the egg is, by virtue of its position, embedded in the moist leaf tissues, independent of the seasons. The grub stage varies in length even among those derived from eggs laid in one day by the same parent, but the average period is about 12 days less during the rains than during the dry season. The pupæ, similarly, develop much more rapidly during the rains.

So far as our observations go, it appears that the female weevil is slow to reach sexual maturity, a minimum period of 25 days having been noted from emergence from the cocoon until the first egg is laid. The minimum period for a generation is thus eleven weeks, with a possibility of four generations per annum. The female lays her eggs in batches of from two to six at a time. The length of life of a female and her egg-laying capacity are not yet known exactly, but in one experiment three females averaged

62 eggs each over a period of three months.

In Yucatan, according to Riquelme Inda (1921), the adult weevil appears in the Agave plantations with the advent of cold weather in November and December. Mating occurs at the end of March or early in April, oviposition taking place 15 to 20 days later. Incubation requires about 39 to 40 days. The larvæ occur in May, June and July, and they spin a cocoon when about to pupate. The pupal stage lasts from August to October, the adults appearing in November. There is thus only one generation a year. The climate of Yucatan, as given by the *Encyclopædia Britannica,* is hot and dry with a limited rainfall. The dry season lasts from October to May, with the hottest months March and April, just prior to the rains. Thus the rainy season is occupied by the young stages of the weevil, while the six months of dry weather are passed in the adult form. The climate of Tanga is definitely humid, the average rainfall at the coast being about 1,200 mm., falling mainly between November and May, but with no month quite without rain. As one proceeds inland the dry season is more markedly unrelieved by showers. The hottest months are February and March, the coolest July and August.

In 1934 Schwenke recorded the widespread incidence of the patches of dead tissues produced on healthy sisal leaves by adult weevils as described above. Because this type of injury is not referred to in Morstatt's paper, he stated that this habit must be a new development in the weevil and only to be explained by a mutation. Morstatt's investigations were interrupted by the War, and his paper is by no means a detailed account of the insect, as indicated for instance by his reference to what we now know to be the main breeding-place for the weevils: "According to a statement, the weevils are also present in the stumps of totally or partially cut Agaves; it is not yet established that they also breed in them." This scarring of the leaves has been observed on various species of Agaves, at least since 1927, and is to be found throughout the whole area inhabited by the weevil. A simultaneous mutation over so large an area is hardly to be suspected. Schwenke was the first, however, to draw attention to this particular habit of the adult weevil and its relation to scarred leaves.

The sisal weevil has not yet been observed to attack or breed in any plants other than those of the genera *Agave* and *Furcraea.*

Distribution.

There appears to be little doubt that *Scyphophorus acupunctatus* Gyll. is a native of Central America, from where it was originally described. It is recorded as a pest of cultivated Agaves in the Federal District of Mexico (Ramirez, 1921) and in Yucatan (Inda, 1921). It is recorded from the States of California, Colorado, and Texas, and Haiti (Leefmans, 1920), from Cuba and the Island of Curaçao (Ballou, 1920). It was first recorded outside the American zone in Tanganyika in 1914 (Morstatt, 1921), and then it appeared in Java in 1916 (Leefmans, 1920). It has since been introduced into Hawaii (Swezey, 1927). A closely related insect, *Scyphophorus sexpunctatus,* is also found on Agaves in Mexico and Southern California (Kleine, 1932) (Fig. 8).

The distribution of the sisal weevil in the African tropics, so far as is known at present, is restricted to a portion of the Tanga Province of Tanganyika. The other sisal-growing districts of this Territory are, from our observations, so far

quite free. It has not yet been recorded in Kenya. No reference to its occurrence either in Mozambique or in the sisal-growing areas of the West Coast has been found in the literature available.

The Tanga sisal area forms a triangle having its base from Moa to Sakura on the coast, a distance of some 60 miles in a straight line, and its apex at Korogwe, 45 miles inland. Then the apex is drawn out into a narrow strip following the railway up to Moshi, the plantations being more or less continuous as far as Mombo, after which they are separated by increasingly large tracts of bush country. As far as Korogwe the climate of the country is influenced by the East Usambara Mountains and the proximity of the sea to produce a moderately high humidity and a dry season not devoid of rain. The climate of Korogwe and beyond is more extreme, particularly in humidity. The sisal weevil was found by us on every estate visited in 1934, from the sea up to Makuyuni, two estates only being omitted in our itinerary. At Makuyuni, they were found only after long search and were very few in number. The next estates to westward produced no specimens. Since then, however, a few weevils have been recorded as far west as Lembeni. The average population density of the weevil is greatest in the coastal belt, east of a line from Moa through Pongwe to the Pangani River, an area of light or sandy soils derived from Jurassic rocks and typically covered with large rounded termite hills. It is least in those estates which lie along the foot of the East Usambara Mountains, where the soil is of a red, lateritic nature. These divisions are subject to local variations which influence the number of weevils present.

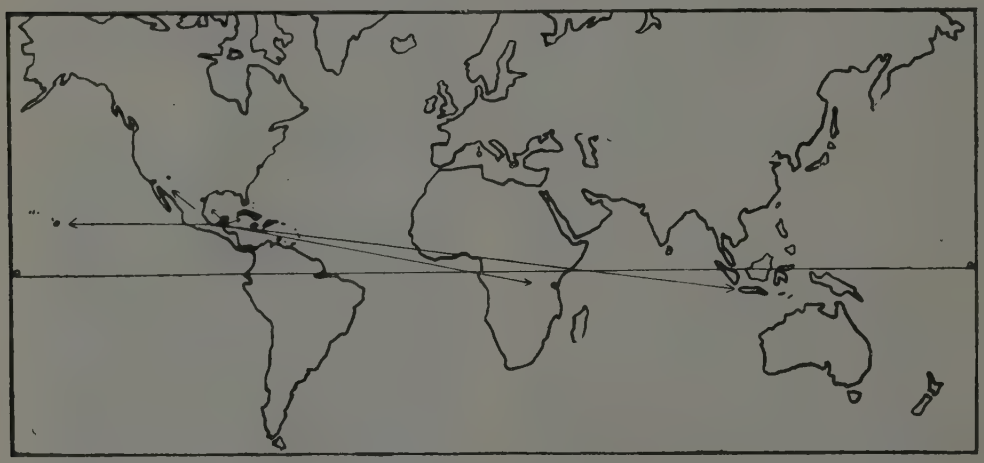

FIG. 8

DISTIBUTION OF THE SISAL WEEVIL, *Scyphophorus acupunctatus*.

Hawaii. California. Colorado. Tanganyika. Java. Jamaica. Texas. Cuba. Haiti. Yucatan.

FACTORS INFLUENCING THE NUMBER OF SISAL WEEVILS.

The availability of suitable breeding places is suggested as being the main factor influencing the number of weevils

in an area, and the main breeding places from the point of number of weevils produced per unit is undoubtedly the stems of plants which have poled.

These stems, or stumps, as they are usually called, weigh up to a hundred pounds or more, and under coastal conditions will remain breeding-grounds for at least eight months. Natural checks on breeding in stumps are as follows:—

(1) Dry climate, which shortens the period taken for the stumps to lose sufficient moisture for them either to be burnt or to become too dry to support weevil grubs. This is to be seen in the estates in the Mombo area, beyond the weevil zone.

(2) Termites, which destroy the stumps. They are numerous in red lateritic soils, and are suggested as being one of the main causes of low weevil population in the estates at the foot of the East Usambaras. The subterranean or low mound building termites are not common in sandy soils, where their place is taken by large mound builders, which are not so active in attacking sisal stumps.

(3) Natural enemies. There are no definite observations on natural enemies of the weevil grubs in this Territory. Ritchie (1923) records three Histerid beetles of known predatory habits, *Hololepta sciosoma* Mars., *Hister geminus* Er., and *Placodes ebeninus* Lew., collected in rotting sisal stumps infested by *Scyphophorus*, but their relations with the weevil grubs are not stated. Work on this subject is proceeding.

The following factors have contributed to the increase in number of stumps available and so to the present increase in weevil population:—

(1) The years 1925-1929 were times of great development on sisal, with the result that from 1931 onwards there have been larger areas of poling sisal than previously.

(2) In 1930 there was a considerable fall in the value of sisal, with the result that economies had to be introduced into the working of estates, one of which was to allow fields to regenerate themselves from suckers rather than to clean them up and replant.

(3) Areas which are now being planted up are mainly old sisal lands recleared, and not new land as heretofore. Old stumps are accordingly to be found in varying degree among the new plantings, up to the limit observed of the unburnt old plant material being stacked up in rows between the young plants! In addition, the new plantings are for the same reason surrounded more or less by older fields which contain poling plants, and are thus easily infected from neighbouring areas.

There are indications that relatively dry seasons are also periods of increased weevil activity. Whether the actual increase in numbers of weevils is as great as would appear, or whether dryness causes the plants to be more susceptible to injury cannot be stated on the evidence available. A graph of the total annual rainfall of Tanga from 1921 to 1934 is given in Fig. 9, and the years in which weevils are remembered to have been numerous on plantations near the coast are shown. The correlation between weevil injury and low rainfall is close. It must be noted, however, that a low average rainfall is not in itself conducive

to weevil attack; in fact, the reverse is suggested above, namely a comparative shortfall of rain or drought.

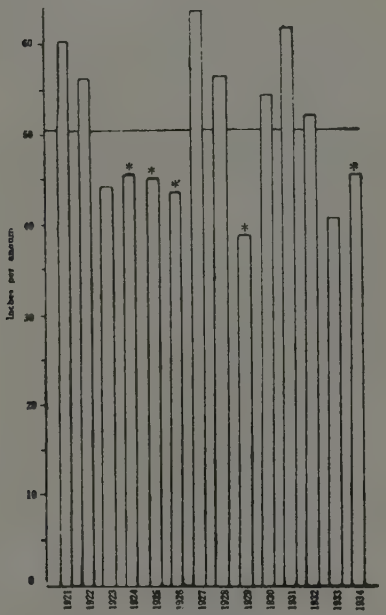

FIGURE 9
Annual rainfall at Tanga, 1921-1934. Years in which damage by sisal weevil is reported to have been greater than usual in plantations near the coast indicated by *

CONTROL MEASURES.

The most satisfactory method of controlling the sisal weevil, as has been emphasized by most previous writers on the subject, lies in the removal of weevil breeding places, i.e. old stumps. The practical difficulties in the way of this are many, particularly when low fibre prices necessitate low working costs. In addition, many estates do not clean up and replant their areas as they become old, but maintain a leaf supply by a succession of sucker growths, and often omit to remove the parent stumps. The ideal practice would be to cut out and destroy all plants as they pole, together with any plants dying of disease. It is generally assumed by plantation managers that the cost of cutting stumps and carrying them to a place where they can be conveniently split up, left to dry, and afterwards burnt, is uneconomic. Trials have been made with a view to rendering stumps innocuous in situ by pouring a solution of sodium arsenite into holes made in the tops. The penetration of the arsenite thus applied is not sufficient to render the whole stump poisonous and prevent weevil grubs developing. Other treatments are under consideration, e.g. boring the base of the stump to assist the more effective introduction of arsenicals, but such treatments are likely to prove more expensive than the complete removal of the stumps. Every endeavour should be made, however, to remove all poled plants at the time when the fields are being cut through for leaf. It is suggested that a sanitation gang might follow the cutters, when there would be no difficulty in moving the stumps to the roads. Such stumps would need to be split longitudinally into at least four pieces, though six is better. The unsplit stump, as mentioned above, may remain a breeding ground for a long time, while splitting, by increasing the rate of drying out, shortens the time during which the stump can support weevil grubs. The following table indicates the rate of drying out of split and unsplit sisal stumps:

TREATMENT	LOSS IN WEIGHT PER 100 LB. AFTER			
	8 days	16 days	26 days	34 days
Unsplit ..	6·4	12·1	18·9	22·4
Split into Two ..	15·0	23·6	33·5	40·3
Split into Four ..	28·3	40·9	49·6	53·9

The next best plan is to cut out the areas as poling becomes general and the leaf-yield low, and, after destroying all the old material, to replant. The destruction of the old material by burning is made easier if the clearing is done early in the dry season, and if the stumps are split, as advised above, to ensure that they dry out and burn completely. A stump may be charred outside and yet the inside may be quite a suitable breeding ground for weevils. If such material is left lying about the plantation during the rains, or if replanting is proceeded with before it has been destroyed, weevil incidence in the new planting will be aggravated.

The protection of nurseries and newly planted areas by trapping the weevils is strongly recommended, particularly on old sisal land. Morstatt (1921) first suggested the use of heaps of rotting sisal leaves and shoots as traps. The method, which has given good results on a number of plantations, is to split stumps longitudinally and to lay them face downwards along the sides of roads and around the newly planted areas. These are examined at least every second day by boys, and the weevils found clustering beneath the traps are collected into jars or tins containing a little kerosene. In hot, dry weather, the traps require to be scraped with a knife every two or three days to provide a moist and attractive surface, and so maintain their efficiency. Traps should not be left in position for longer than five weeks, after which time they must be burnt, or at least split into small portions in order to kill any grubs or pupæ that might be developing inside them. New material should be substituted for that destroyed. It must be emphasized that baiting alone is only a temporary measure, useful in protecting new areas, and reducing the weevil population of an estate during times of unusually high incidence. It must be accompanied by a reduction in the number of breeding places if its effect is to be permanent. It would be slow and expensive endeavouring to eliminate the weevil by trapping in areas of mature sisal, since all work is restricted to the roadways until cutting has been done. Moreover, it is doubtful if the movement of weevils to the borders, where they would come under the influence of the trap, would be greater than the numbers bred in poled plants inside the area.

The training of a small sanitation gang and its continual employment throughout the year is suggested as a sound means of keeping the weevil down. The untrained native is careless, and liable to damage more healthy plants in looking for weevils, or removing old stumps, than the weevil itself would do. A little training soon produces good effects, and a small gang permanently at work, provided that they are started on the right lines, will do much good, as has been found with the coffee borer. Payment by reward for weevil collection is open to abuse.

Finally, there remains to be mentioned the value of planting out new fields ahead of or early in the first rains, so that the young plants are well established before the dry season sets in. Care in avoiding bulbils that are already infested with weevils from the nursery, and suckers that have had their roots carelessly cut off so as to damage the base of the leaves, will reduce the number of re-plants necessary. Similarly, deep planting, a fault not uncommon in sandy soil, should be avoided, because plants which are deep in the soil are slow to grow and attract weevil.

ACKNOWLEDGMENTS.

We have to record our indebtedness to Mr. G. W. Lock, Agricultural Officer, Sisal Experiment Station, Tanga, for his assistance in obtaining the life-history data, and to the Imperial Institute of Entomology for kindly providing a summary in English of Inda's paper.

SUMMARY.

The sisal weevil is a pest of sisal in the Tanga Province of Tanganyika, where it appears to have been introduced, together with its host plant, from its original home in Central America.

It attacks young plants, weak plants, and plants which have flowered. Its main breeding ground is the plant base subsequent to the production of the inflorescence ("poling").

The life-cycle occupies from 50 to 95 days. The stages are described.

Factors influencing the number of beetles present are discussed, and control measures suggested.

REFERENCES.

Ballou, H. A., 1920.—Agric. News, Barbados, XIX, No. 462, p. 22.

Harris, W. V., 1934.—Agric. Dept., Tanganyika, Entom. Circular No. 3.

Inda, J. R., 1931.—Mem. Soc. "Alzate" Mexico, XXXV, pp. 305-308 (reprint).

Kleine, R., 1932.—In Sorauer's Handbuch der Pflanzenkrankheiten, V, 2.

Leefmans, S., 1920.—Meded. Inst. Plantenziekten, Buitenzorg No. 44.

Morstatt, H., 1931.—Tropenpflanzer, XXXV, pp. 33-37.

Ramirez, R., 1931.—Rev. Agric. San Jacinto, V, 4, pp. 202-205; in Rev. App. Entom., A, IX, p. 300).

Ritchie, A. H., 1932.—Agric. Dept., Tanganyika, Ann. Report, 1932.

Ritchie, A. H., 1933.—Agric. Dept., Tanganyika, Ann. Report, 1933.

Schwenke, E. H., 1934.—Tropenpflanzer, XXXVII, pp. 322-325.

Swezey, O. H., 1917.—Proc. Hawaii Entom. Soc., 1916, pp. 403-404; in Rev. App. Entom., A, XVI, p. 168).

1934.—Kew Bulletin, 1934, No. 3.

Essential Oils

III.—Oils from Indigenous Plants

CEDAR WOOD OIL

By V. A. BECKLEY, *M.C., M.A., A.I.C., Senior Agricultural Chemist, Kenya Colony.*

East African cedar wood oil, as it is known on the market, is now firmly established, and obtains about the same price as the old-established American cedar wood oil. In 1935 the exports of this oil were 2,844 gallons—more than double the quantity of other oils exported from Kenya and Uganda.

As its name indicates, it is obtained by the distillation of the East African cedar (*Juniperus procera*, Hochst.). In Kenya the oil is a by-product of the cedar timber industry, the sawdust being used for distillation and the waste wood for steam raising. The cost of production is thus very low.

According to the textbooks, the yield of oil is 3 to 4 per cent, but working on the commercial scale, where it does not pay to carry on the distillation far, the yields are between 1 and 2 per cent. In a series of forty-five distillations on a semi-commercial scale carried out in these laboratories the yields varied from 0.96 per cent to 2.57 per cent. Probably, had the material been stirred and the distillation carried further, much larger yields would have been obtained. Incidentally, it is only worth while distilling fresh sawdust or sawdust a few months old; the oil evaporates from the sawdust rapidly. The figures below for a series of distillations on sawdust of varying ages illustrate this:—

Age of Sawdust.	*Yield.*
Fresh ...	... 1.42 per cent.
2 years old	... 0.28 per cent.
7 years old	... 0.02 per cent.
11 years old	... Trace.

The distillation of this oil gives certain difficulties. The material is finely divided and packs down tightly. In a series of distillations undertaken in a large still, holding about a ton of sawdust, it was noticed that after a few hours the amount of oil distilling rather suddenly dropped very considerably, and continued distillation gave very little oil. The yield was well below 1 per cent. Careful examination of the discharged sawdust showed that a zone of wet sawdust was developed part way up the charge. This sawdust sank in water, leaving a trail of oil. Evidently, condensation had occurred in the sawdust, sealing it against the passage of steam, and what was occurring when the oil flow decreased was condensation at the bottom of the seal, with evaporation at the top. Long continued steaming moved the zone of wetness up the charge very slowly. The ratio of height to diameter in this still was about 2:1. Half charges in this still distilled normally, gave yields more than double those from full charges, and the spent sawdust was dry. It was concluded that for efficient distillation of cedar sawdust the ratio of height to diameter must not exceed 1:1. This was confirmed by laboratory experiments and observations on commercial stills.

On the laboratory scale it was also found that poor yields were obtained if the sawdust was packed into a removable cage. Parallel distillations upon sawdust packed directly upon a false bottom gave yields three time as great. The steam tended to pass to the sides of the cage

rather than through the mass of material. Stirring and ramming the sawdust after the oil flow had decreased once more gave rise to a good flow of oil. The two essentials in distillation of cedar sawdust may be summarized as: (i) the still must be squat, the ratio of height to the diameter must not exceed 1 : 1; (ii) the sawdust must be packed on a false bottom and fill the whole still.

East African cedar wood oil is sweeter smelling than the American; the odour is reminiscent of vetivert rather than of normal cedar wood. It contains large quantities of cedar camphor—an alcohol. In some cases, the oil will solidify to a mass of "figged" needle crystals of cedrol. It has been suggested that exposure to light and air increases the cedrol content, but this is only apparent. It has not been possible to determine the cedrol content of oils accurately. The usual method, boiling with acetic anhydride, destroys much of the cedrol, converting it to the hydrocarbon, cedrene. Many other methods have been tried, without success. Treatment of a petroleum ether solution of the oil with strong phosphoric acid gives a precipitate, the amount depending on the cedrol content. By means of this test it was possible to ascertain very roughly the true cedrol content of the oils.

Cedrol is not wanted by the users of the oil, and quantities filtered from oils have accumulated. In a series of distillations made at the Scott Agricultural Laboratories, the oils, after being dehydrated, were cooled to a temperature of 5° C., and the resulting crystals filtered off. The highest yield of solid was over 75 per cent. This oil on cooling set to a firm, buttery mass of figged crystals. A few gave no crystals under this treatment, but, on long standing, from all except two a few crystals separated. (These exceptional oils will be discussed below.) One cannot definitely connect cedrol separation with age of trees. In two cases sawdust from young trees gave 51 per cent and 76 per cent cedrol separating, while in a third case 23 per cent separated. Sawdust from old trees gave oils from which very variable amounts of cedrol crystallized, sometimes more than 23 per cent. It is, however, suggestive that from the oils from young trees relatively larger amounts of cedrol crystallized than from the oils from old trees in close proximity. It also appears that from the oil from well-seasoned timber rather less cedrol crystallizes than from the oil from fresh timber.

The colour of the oil is most variable. Some few lots have been pale yellow, some red to red-brown, while the majority are brown to nearly black. At first it was believed that this colour was connected with aspect or locality. Thus for a long time all oils distilled at one sawmill at Gilgil were pale yellow, those from an Njoro mill red, while all oils seen from a Thomson's Falls mill were nearly black. When, however, a sawdust from the Njoro mill gave a pure yellow oil, identical with the Gilgil oil, and the oils from another area varied from pale red to dark brown, this hypothesis fell. The still used in the series of distillations was the same, steam pressure was maintained at 20 lb. per square inch, and each distillation was continued for a definite time. The hypothesis is advanced that there are different varieties or strains of *Juniperus procera*, each of which gives a particular coloured oil. One distiller of experience claims that it is possible to differentiate between these, and by choosing the tree to produce whatever coloured oil it is desired. Variation in colour of oil would of course tell against it in the market. All cedar wood oil is redistilled in London, the

coloured part remaining behind as a tar, and the oil as marketed is either pure white or very faintly yellowish.

The two exceptional oils mentioned above were the pale yellow oils from Gilgil and Njoro. It was impossible to cause any crystals to separate from either even after three months in a refrigerator. In both of these oils the phosphoric acid test showed there to be considerably more cedrol than in an oil from which cedrol had crystallized. Something in these oils prevents the cedrol from crystallizing. On careful fractionating, which was rather vitiated by the appearance of cedrol in all fractions, the only difference lay in the first most volatile fraction. The quantities of this were too small to permit of chemical examination, but that from normal oil had an odour of limonene; that from the pale oil an odour of pinene. It has not been possible to follow this up, but when opportunity permits the subject will be pursued.

No ordinary treatment has caused cedrol to crystallize from this oil. It did from the fractions obtained by distillation *in vacuo*. A quantity of this oil was handed to the Veterinary Research Laboratory for use as a clearing agent in histological work. When the dehydrated animal tissue was added, the oil crystallized to a soft buttery mass. It was also found possible to bring about crystallization with dehydrated living plant tissue. On melting and cooling, the oil again refused to crystallize, but did so on seeding with a few crystals of cedrol. A similar observation was made by the author some years ago with an American cedar oil. These last experiences are probably of no value, but are merely recorded here as a matter of interest.

Cedar wood oil is an oil of considerable commercial value. Being purely a by-product, in especially large quantities where cedar is being milled for pencil slats, its cost of production is very low indeed. There is a tendency for it to be over-produced, and, as far as the writer has been able to ascertain, stocks have accumulated. Should the demand increase, there is no doubt that production would readily follow. Unfortunately, until last year, the export of this oil was not quoted separately in the Customs returns, but the increase from 200 gallons in 1927, when the experimental shipment to the open market was made, to last year's export of over 2,800 gallons, shows how readily the production can grow. The price of the oil is low, 1½d. to 1/4d. per lb., from which must be deducted the cost of redistillation, but, being purely a by-product, such low prices are profitable. As the main product the profits would fall considerably. Intending producers should be very careful, and explore the possibilities carefully before entering upon production.

The constants of the oils examined in these laboratories are:—

Specific gravity at 15.5° C.: Average, 0.9453.
Rotation at 20° C.: −47.89° to −63.80°.
Refractive index at 20° C.: 1.4999 to 1.5141, but mainly about 1.5050.
Acid value: 0.56 to 1.12.
Ester value: 0.94 to 5.66.

Land Utilization as a National Problem

With Special Reference to Kenya Colony

By COLIN MAHER, *M.A., Dip. Agric. (Cantab.), A.I.C.T.A., Agricultural Officer, Kenya Colony.*

INTRODUCTION.

There is a growing tendency in modern times to neglect individual "liberties" and to control the individual citizen more and more in the general interests of society. Whether the control issues from Dictator, from Soviet or from democratic constitutional government, the effect is similar in that the freedom of the private person is curtailed; he has to mould his life to accord with the scheme which the controlling authority has decided is best for the society of which he is a unit. The powers of an economic giant may or may not be used with the utmost benevolence with regard to the wage-earners concerned in production; the authority of the modern State ensures that a certain amount of restraint at least is imposed upon the masters of industry by means of regulations in respect of minimum wages, hours of employment, factory conditions, and so on.

The attitude of the States of to-day is in sharp contrast to the old *laisser-faire* or "it will all come right in the end" policy of industrial and social economics of the nineteenth century, to which the slums of so many great cities stand as dreary monuments. If the smoky tenements and the monotonous rows of villadom are witnesses to the relentless single-purposed advance of industry, abetted by cynical municipalities, during the nineteenth century, where shall we look for the tangible results of unfettered "private enterprise" in the agriculture and forestry of the past? We may turn to China with her teeming millions gathered round the residual fertile soil near the great rivers; we may turn to the scenes of desolation in parts of India; we may observe the deterioration through over-grazing on the ranges of the western states of America, and the destruction of the surface soil and consequent "blowing" of the prairie lands which were ploughed up during the wheat boom of the nineteen-twenties; we can see where destruction of forest and grassland or reckless cultivation all over the world, and the resultant soil erosion, has followed the advent of "civilization" and its accompanying greed for more wealth; we can trace the downfall of mighty empires and their cities through heedless destruction of Nature's covering to the soil, while vast irrigation works which supplied the water which was their life-blood became choked with silt and were left as relics in a sandy desert of a forgotten race.

The pioneer is commonly hailed as the benefactor and the father of young countries; not seldom should he rather be execrated as a greedy self-seeker who, regardless of the claims of future generations, destroys Nature's accumulated treasures with a nonchalant hand, and starts a country on a progressive deterioration which will take his children and their children all their ingenuity and devoted labour to check. The untutored native is not better; but in his primeval state, disease, war and famine were the grim allies which guarded the forests, the soil and the rivers from destruction, and which, in the past, generally diminished the dangers of over-population, whether of men or of stock.

Since agriculture is the mother of industry, it is strange that it is only of late years that nations have come to appreciate the urgent necessity for protecting the resources of their lands; assets which should not be at the mercy of private greed, but which should be handed down, unimpaired, to the coming generations. There is growing then, tardy but sure, a recognition that there lies an imperative duty with the government of a country to prevent the dissipation of a country's wealth and the impoverishment of its people's children by misuse or ill-considered development of the natural resources of that country; the necessity is being more widely understood of limiting the destruction of forests, soil and water supplies, and of guiding the development of the country, with the exercise of such authority as need be, along wise and considered lines which will be for the greatest ultimate good of the community.

This point of view is exemplified by the opening paragraph of the Foreword to the Natural Resources Board Report, submitted to the President of the United States of America at the end of 1934:—

". . . The natural resources of America are the heritage of the whole Nation and should be conserved and utilized for the benefit of all of our people. Our national democracy is built upon the principle that the gains of our civilization are essentially mass gains and should be administered for the benefit of the many rather than the few; our priceless resources of soil, water, minerals are for the service of the American people, for the promotion of the welfare and well-being of all citizens. The present study of our natural resources is carried through in this spirit and with a desire to make this principle a living fact in America.

"Unfortunately this principle has not always been followed even when declared; on the contrary, there has been tragic waste and loss of resources and human labour, and widespread spoliation and misuse of the natural wealth of the many by the few.

"The conservation movement begun a quarter of a century ago marked the beginning of an organized national effort to protect and develop these assets; and this national policy was aided in many instances by the individual States. To some extent the shameful waste of timber, oil, soil, and minerals has been halted, although with terrible exceptions where ignorance, inattention or greed has devastated our heritage almost beyond belief."

Land Tenure as a Factor Affecting Land Use.

Man in his most primitive state probably had no conception of land as a thing which could be owned. He owed his right of hunting over any particular area, and later his right of grazing his cattle, simply to the power of his arm. Later the powers of the individual occupiers were fused into the power of the tribe which, as a larger unit, in turn wandered at will over large territories; eventually, owing to the growth of population, and as a result of pressure from several opposing directions, each tribe obtained tacitly its own territory, the bounds of which, however, were still dependent upon its ability to maintain its fighting strength at least at its initial level.

This latter stage of social development is that which has been attained by the pastoral tribes of Kenya, though their tribal boundaries were deprived of elasticity and in some cases were altered on the advent of British rule.

While such a system has a flavour of communism, it is not correct to compare

it with the modern idea of that doctrine of social organization. The former system consisted largely of lack of control over the land so long as it was retained for the joint use of the members of the tribe; the more modern theory necessitates a control by authority delegated from the masses so that the best possible use is made of the common land and property from the point of view of the community as a whole.

Agriculture involves a more settled existence on the land than the herding of cattle requires, and usually implies individual holding or right of cultivation even under a "shifting cultivation" system. The open-field and common grazing system of early medieval times in England represents a transition from holding communally to individual ownership, though the farmer usually had only a customary *right* of cultivation and did not own the land, which might be "held" from a feudal overlord on the basis of a weekly or yearly labour or military service, or, in later times, on the basis of a commuted cash rent.

A somewhat analogous system to the Saxon "open-field" system—with the omission of the wasteful custom of subdivision of the land—is described in the Report of the Committee on Native Land Tenure in the North Kavirondo Reserve, quoted by Liversage, in his important paper on "Tenure of Native Land in East Africa" (1), who also refers to the somewhat similar *Githaka* system of the Wakikuyu.

Liversage, in the paper mentioned above, traces the probable development of land tenure in the native reserves, with the stimulus of increasing commerce, towards individual proprietorship. He utters a grave warning, with examples taken from countries all over the world, of the likelihood of a state of peasant indebtedness coming into being amongst the natives of Kenya; he touches upon the dangers, too, of excessive subdivision and fragmentation of holdings and of the appearance of a parasitic landlord class. These are real perils, especially if the native population increases within the next few decades.

It may be observed that, while fragmentation was practised in order to secure equitable division of the arable land, subdivision was unusual in the English open-field farming. Lipson (2) says: "From the earliest times the normal type of peasant holding was the yardland, or virgate, consisting of thirty acres scattered in strips over the open fields. These virgates were never divided amongst heirs, and for centuries had passed from father to son without losing their unity." There is some doubt whether this indivisibility was due to feudal law or to custom based on economic forces, but the fact remains that excessive subdivision rarely occurred; further, with the break-up of the manorial system, the commutation of services for rents, and the coming of enclosures, the various farm lands tended to be brought together in compact blocks.

Subdivision of lands in England never proceeded to the extent to which it took place in France, in which it was noted in the last century that there were three millions of peasant proprietors whose land averaged only 2½ acres apiece (1). The Black Death in 1348 and 1349 is said to have reduced the population of England by half. The population increased but slowly for centuries, while the rise of a class of wage-earning agricultural labourers and the demand for artisans and industrial workers in the towns helped to absorb the surplus. The Industrial Revolution of the eighteenth and nineteenth centuries corresponded with

a rapid rise of population which was almost entirely absorbed in the new industries, while pressure upon the land was not increased; during the last fifty years it has actually been Government policy in England, for various reasons, to encourage settlement on the land and to attempt to check the drift of the agricultural population into the towns. At the same time, the nature of the climate, the relatively thin agricultural population, and the improved methods of husbandry adopted since the eighteenth century have prevented deterioration of the agricultural lands.

After this brief digression to survey the way in which present conditions have been derived in England, we may turn again to contrast the probable development of conditions of tenure amongst the native tribes of Kenya.

The pastoral tribes graze their lands communally. The evils of this system were well known in medieval England (3):—

"Unable to provide winter keep, and fettered by the common rights of pasture which each of the partners enjoyed over the whole of the arable land, farmers reared lambs and calves under every disadvantage. During the summer months, when the horses and cattle were tethered on the unsheltered balks, they lost flesh and pined in the heat. Ill-fed all the year round, and half-starved in the winter, the live stock dwindled in size. The promiscuous herding of sheep and cattle generated every sort of disorder. The common pasture was pimpled with mole-heaps and ant-hills, and, from want of drainage, pitted with wet patches where nothing grew but rushes. The scab was rarely absent from the crowded common fold, or the rot from the ill-drained ploughland and pasture. No individual owner could attempt to improve his flock or his herd when all the cattle and sheep of the village grazed together on the same commons."

The deterioration of pasture and soil is much more rapid and severe when land is overgrazed in the tropics, especially in the low rainfall areas. A system of paddocking and individual tenure may develop in some of these pastoral areas, right of tenure being based on the primitive right of the squatter, or "What I have I hold." But this will not assist unless the native conception that wealth may be estimated by the numbers of stock is combated successfully, and rigid culling, voluntary or enforced, is carried out. There may also be trouble from the dispossessed or landless members of the tribe, too late in the scramble for land, who will inevitably be found.

A system of rotational grazing, carried out communally, will delay the deterioration, especially if limitation of stock is enforced concurrently. It is very doubtful, however, if this system could be carried out indefinitely with the advance of the social organization of the tribe in accordance with the usual trend of social development, whereby individual tenure tends to replace joint holding of grazing and cultivating rights.

Liversage's views as to the probable course of social and economic development in the native reserves appear to be absolutely sound, and are in agreement with the course of development which has taken place amongst peasant cultivators in other countries. He gives striking examples of the evils which have arisen elsewhere, and the warning should not fall on deaf ears. The possible relief given by industry to the pressure of population in the agricultural areas is, however, hypothetical. There are yet few signs of such an "industrial revolution" in Kenya as may serve to absorb the surplus agricultural population which may be found within the next few decades unless some method of limitation of population is adopted. The "outside labour market" would seem to be largely dependent on white settlement, and is not capable of indefinite expansion. Meanwhile, sub-

division and fragmentation and the accompanying uneconomic use of the land would reduce the numbers of natives which could be carried by the land, while the entrenchment of vested interests would make more and more difficult the protection of the natural resources of Kenya, the distribution of population according to the carrying capacity of the land, and the implementing of a sound and reasoned scheme of national development.

Planning the Use of Land.

The following words occur in the first paragraph of the introduction to the section on "Land Utilization and Land Policy" in the Report of the National Resources Board of the U.S.A.:—

"The traditional American attitude toward land has been to develop and exploit it as rapidly as possible, with little regard for the consequences. This, to be sure, was the natural attitude of a new nation reacting against the economic restraints of mercantilism and the remnants of medieval land tenure, and confronted with an apparently illimitable array of resources. This attitude contributed to rapid expansion and development, but at the same time produced a planless, crazy-quilt pattern of land use, destroyed or impaired a large proportion of the nation's irreplaceable resources, and wrecked the hopes, aspirations and the very lives of untold thousands of people.

"In no other field of economic activity has the doctrine of *laisser-faire* been given freer rein than in the use of our agricultural lands. Farm lands have been used and abused and bought and sold as mere commodities, practically without restriction. Indeed, the extreme of *laisser-faire* has been reached with respect to some of the Federal Government's own lands, on which unrestricted grazing has been permitted, even to the point of destroying valuable range resources."

The present age is characterized by speed and change. The swiftness of the aeroplane and the motor car have replaced the pace of the horseman and the pedestrian; the words of the broadcaster are heard by millions at a time where news formerly travelled slowly from man to man; where institutions formerly slumbered peacefully from century to century, social change now occurs almost from year to year; forces of destruction increase and the consolidation of anti-social practices occurs no less swiftly than constructive tendencies are directed towards the common good. At such a time the need for wise national planning should require no emphasis, and the urgency for this direction of the development of a country is no less apparent: the greater the delay the greater the ultimate upheaval in setting accumulated wrongs to right. In many cases delay is suicidal; thus America announces that she has already permanently lost to beneficial occupation 35,000,000 acres of arable land through soil erosion.

If we leave out of account the land which is required for townships, purely residential purposes and industrial areas, the chief uses of land are for forest, pasture, arable cultivation, and for the purposes of conservation of water supplies. These various uses may be dealt with under subheadings.

Forest.

Forests are of supreme importance in tempering the climate of a country, by tending to reduce the extremes of temperature in either direction, by preventing the desiccation of the agricultural lands by dry winds, and by encouraging generally the maintenance of a humid atmosphere suitable for agricultural enterprises. For optimum results, probably an area equivalent to at least 20 to 25 per cent of the agricultural and pastoral lands should be under forest for the above purposes, and there should be no wide expanses of land unprotected by adequate windbreaks.

Erosion of the mountain and hill sides should be prevented by keeping them clothed with forest growth. Excessive run-off and silting up of the rivers will also be prevented, and riverine forest should also be protected, in view of its importance in relation to the protection of water supplies and the prevention of erosion.

The preservation of forest or afforestation is particularly important in the catchment areas of streams in order that a regular flow of water may be assured and violent floods prevented.

Pasture.

A certain proportion of land in arable farming areas should be under temporary or permanent pastures in order to enable the use of stock in the farming system. The drier areas of a country are often more suitable for extensive grazing than for cultivation. Finally, all slopes more severe than about 10 per cent should be under grass rather than under arable cultivation. (In general, slopes of more than about 25 per cent should be under forest.) This will include the foothills of mountains. Land under native cultivation is often on very steep slopes, and it is not then practicable to afforest the area, though it should be attempted to secure the maintenance of transverse strips of forest; but catchment areas and the tops of hills should at all costs be kept well timbered. In such cases the technique of cultivation must be adapted to the particular circumstances, and it must be remembered that, where labour is cheap, anti-erosion methods, such as walling and the building of bench terraces, can be and are used, although they would be quite uneconomic on land in European occupation.

Arable Land.

Crop husbandry will normally be practised on relatively flat land up to slopes of 10 per cent. Land of this description is found on plains and below the foothills of the mountains. It is certain that under the misdirected impulses of private enterprise, land is often developed for farming which is unsuitable (*a*) for any arable farming, (*b*) for the particular type of farming which is being attempted. Sub-marginal lands of the type included under both headings will comprise—

(i) land with poor or shallow soil;
(ii) land liable to erode very severely on cultivation owing to texture, shallowness or topography;
(iii) land unsuitable for settlement for arable farming owing to the high "climatic risks"; that is, the high probability of droughts or other dangers, such as hail.

The decision as to which are "sub-marginal" lands from an economic point of view will vary from year to year with the fluctuation of world prices for produce. A Government must take a broader view, however, and discourage settlement on land the cultivation of which promises to be unprofitable over a number of years. Means for discouraging settlement in certain "zoned" areas, such as the publishing of statements that no schools or other social services will be provided in these areas, are discussed in several American papers on land utilization.

The level for land which is considered sub-marginal from a native point of view is probably very low; but consideration must be given to the prevention of the ruin of initially poor land through the increase of population or through overstocking.

Economic theory of the past, largely based on European conditions, has considered that sub-marginal lands are cultivated or are automatically thrown out of cultivation according to the profitableness or otherwise of cultivation with the

prices which are current for agricultural produce.

In fact, the continued cultivation of these sub-marginal lands may be the source of considerable administrative difficulties and social unrest. The U.S.A. proposes to remove from arable farming 450,000 sub-marginal farms, comprising 75,000,000 acres, during the next fifteen years. The settlement of these poor families, many of whom have already involved considerable charges on the State through rendering obligatory the provision of uneconomic social services, is an administrative problem of no small difficulty.

The National Resources Board comments: —

"The huge waste of human and economic resources which has resulted from repeated attempts to farm land of poor agricultural quality calls seriously in question the wisdom of a *laisser-faire* policy, which permits inferior land to be settled in response to the desire of interested promoters and local 'booster' interests, without regard to the capacity of the land to sustain a stable and profitable agriculture and long-time requirements for expansion of the agricultural acreage. There is a legitimate public concern in keeping settlers out of areas where they cannot make a living and consequently will require recurrent provision for public relief; in discouraging sparse settlement in the interest of social welfare and economy of governmental costs; and, finally, in preventing over-expansion of the cultivated area, to facilitate the adjustment of farm production to demand."

There is a danger that the farming of unsuitable lands, or the cultivation of the wrong crops, may result in the total loss of these lands to the community through their complete ruination—so that they are subsequently unfitted for the cultivation of any other crop, for pasturage, or even for forest.

A system of local "zoning" is proposed in the U.S.A., by which development along the correct lines could be assured in any district and compact blocks of settlement could be made which would reduce the cost of social services as far as possible, while the amount of "tax delinquency"—as it is termed in American phraseology—would be diminished.

Water Supplies.

"Water policies and land policies cannot be planned except as taken together." (National Resources Board Report: Foreword.)

This statement is apparently a truism; as with many truisms, there lacks neither necessity nor opportunity for re-statement. The fate of ancient irrigation schemes, the silting up of dams in U.S.A. and South Africa, such instances as that of the Vancouver Water Board mentioned by Maclagen Gorrie (4), all go to show how often and how fatally this vital principle is neglected.

Without water there can be no life, yet the preservation of water supplies in countries where water is not superabundant is too often left to chance.

Water is not merely important for domestic uses and for the tending of stock. The rivers have an importance in some countries for navigation and for the furnishing of water for industrial purposes. In many countries the power of mountain torrents is harnessed in order to supply electrical power, while water is needed for irrigation purposes in order to support a large portion of the population of the world.

The place of forests in water conservation has already been mentioned. The prevention of soil erosion and excessive run-off from the agricultural and pastoral land is also intimately related to this question. Misuse of the land through overcrowding of people or stock can have the gravest effects upon the future of a country through the influence exerted

upon the water supplies of the present and future; no existing difficulties, nor hampering legislation, should be allowed to interfere with the provision of measures, by foreseeing statesmanship, which will enable the future water supplies of a country to be fully protected.

Land Utilization in Kenya.

Forests.

A comprehensive report by Nicholson in 1931 covers the field of the development of forestry in Kenya in an admirable manner (5).

He summarizes the forest position in Kenya from the standpoint of direct utility as follows:—

(1) The existing area of merchantable forest of 1,471 square miles will prove insufficient to meet the demands of the future population of Kenya if the latter expands according to expectations.

(2) It is estimated that 3,125 square miles of merchantable forest will be required and that this figure can be obtained by the planting up of certain bush and grass lands included in forest areas.

(3) A more even distribution of forest must be achieved by the establishment of new forests in treeless tracts.

(4) Finally, if the estimated area of 3,125 square miles ultimately proves in excess of local requirements it is extremely probable that the area in excess can be profitably devoted to the production of timber for export purposes.

The uses of forests in Kenya, from the standpoint of indirect utility, are summarized as follows:—

(1) There are extensive areas of forest which should be demarcated and conserved as being of importance from the point of view of climate and water supply.

(2) There are certain tracts where large scale afforestation operations will improve climate or water supply.

(3) Forest cover should be maintained along all perennial stream banks, and protected by legislation.

(4) Windbreaks should be established by individual or co-operative efforts in all dry, wind-swept localities which are economically productive.

There can be little or no criticism of these recommendations.

Nicholson makes some suggestions as to some of the areas which should be considered as of major climatic importance, but he observes that "the full extent of the areas of land in Kenya which should be kept under forest or afforested from the indirect utility standpoint is not as yet known." No time should be lost in determining this question and taking measures accordingly. Land in areas which it is considered should be under forest should not be alienated, either for native or European occupation, except as forest, while lands already alienated and which are not in proper use should be restored to forest or pasture by such means as may be devised before they are lost permanently to the community through erosion.

The use of windbreaks has been generally neglected throughout the Colony. The row of spindly trees of *Grevillea robusta*, which is commonly exhibited as a "windbreak", in no way deserves the term, since the penetration of wind between the trunks deprives the row of trees of most of its value as a shelter belt. It is rarely realized that the inevitable loss of crop in the region of root competition with the trees of the windbreak is more than compensated for by the

benefit derived by the crops beyond the range of root competition but within the area sheltered by the windbreak.

The planting of windbreaks should be regarded as essential, not only in the agricultural areas, but in the pastoral areas of the Rift Valley, the Laikipia and Kinangop plateaux, the Uasin Gishu plateau, the Thomson's Falls district, and in all the native pastoral areas in which the rainfall is sufficient to permit of the establishment of trees. The prevention of desiccation of the soil over large areas of the Colony should be treated as of no small importance in its relation to the maintenance and increase of the wealth of the country.

Apart from the value of trees in protecting crops and preserving a humid atmosphere, their direct economic value should not be forgotten. Lands, which may be rapidly and permanently destroyed for human use if devoted to cultivation or pasturage, may yield a steady income if used for tree planting. Timber will always have value for building purposes and for fuel, while in some localities of Kenya quick-growing trees have a value for pit-props. Nicholson observes that "In Kenya, owing to favourable soil and climate, forestry should be more profitable than in Europe; I have made detailed calculations, based on present costs and yield, which show that one can afford to pay from Sh. 200 to Sh. 250 per acre for forest land to be afforested and still obtain a return of 5 per cent on the capital invested. There are few agricultural crops which can give such steady returns as forestry can be expected to give." There are, in addition, tree crops such as wattle, perhaps cinchona and tung oil, kapok, and others which in certain districts may have an economic importance in addition to their function of conserving soil and moisture.

Forestry is the nurse of agriculture, and no means of increasing fertility is known which can compare with the slow but sure building up of the soil which is accomplished by forests. The Kenya Forest Department employs a method of establishment of forests by controlled shifting cultivation which enables reafforestation to be carried out cheaply, while allowing the cashing by the natives of some of the fertility which has been banked in the soil during ten or twenty years growth of timber. Such a system depends for its success on adequate control and the prevention of too long an interval between clean felling and replanting. Nevertheless the adaptation of such a system should be possible in the native reserves and on European farms on which native "squatters" are considered to be necessary.

Pasture.

The improvement and correct utilization of the pasture lands of Kenya is a matter of the greatest moment. The remedy is obvious in the agricultural or mixed farming areas; that is the paddocking of the grazing land and the improvement of the indigenous herbage by intensive controlled rotational grazing or the planting up of superior grasses, either indigenous or exotic. The question of the preservation and improvement of large stretches of grazing land in the Colony, where the annual rainfall is only 15 to 30 inches per annum, is a more complicated problem. Maclagan Gorrie deals very ably with analogous problems in America in his recent memoir (4) in which he discusses at length the degradation of grazing lands, and mentions remedial measures, such as deferred rotational grazing. The example of the Navajo Indian Reservation, New Mexico, should serve as a grim warning as to the possible fate of some of the native re-

serves of Kenya. He tabulates the chief causes of deterioration in range lands as follows:—

(1) Premature grazing when vegetative growth is just beginning in the spring or the break of summer rains.

(2) Continuous grazing without any respite.

(3) Overgrazing by trying to feed too many animals off too few acres.

(4) Trampling and puddling the soil when it is soaked.

(5) Using the wrong kind of stock or the wrong mixture of classes.

(6) Bad distribution through concentration of stock at watering points, night bedding grounds, freshly burnt areas, or on succulent forest fringe.

Maclagan Gorrie observes that: "The one point in live stock management on which all in the United States are agreed is the calamitous consequences of free grazing on their public domain, which is an exact parallel of the Indian village grazing system. . . ." He adds that Government need not own the ground outright to control it effectively, and refers to the system of pastoral leases which is being effectively used in Australia in the control of grazing lands.

This is not the place to discuss questions of detail, but it is evident that some control over grazing lands should be exercised by Government in Kenya. In native areas doubtless some permit system could be evolved by which leases could be issued by Local Native Councils, while the rate of stocking would be subject to control. The destructive goat should be progressively eliminated, since experience in America, India and Europe alike is to the effect that this animal is supreme in its power of impoverishing a country and its people.

Arable Land.

The problem of the proper utilization of land is one of such importance to the whole body politic that it is at least arguable that Government should assume powers of far more drastic control than it has exercised in the past. The "poor white" is a charge on the community; the native living on a mere subsistence scale is a drag on its economic progress. Both types of human liability to the community are likely to be found if no firm and wise guidance is exercised, on broad lines, in the direction of deciding as to which land should be cultivated, what precautions should be taken against soil erosion, what area of land constitutes an economic unit for cultivation, and what crops should be grown; loans made to farmers by the State can only be sound if there is some control by the State in these respects. These questions are largely bound up with that of land tenure, which will be discussed later.

Water Supplies.

The provision of adequate water supplies is intimately related to the subjects discussed under the headings of Forestry, Pasture, and Arable Land.

In the first place, the afforested mountains contain the reserves of water which supply the rivers, while hill sides and river banks must be timbered to prevent erosion and run-off and the silting-up of stream-beds and reservoirs. At present the amount of afforestation for these purposes is inadequate, while destruction of forest other than that in special forest reserves has been carried on with impunity and with disastrous results. There appears to be no legislation at present by which the diminution of stream flow

through deforestation and erosion can be checked.

In the pastoral areas the shortage of water is a major factor in promoting serious erosion through the congregation of large numbers of stock around the watering places. The provision of bore-holes may alleviate the position in some regions. Elsewhere, bore-holes are useless, since there are no water-bearing strata at economic depths, and reliance for supplies of water must be placed upon surface run-off; this particularly applies to the great plateaux, where a hard lava lies under a relatively shallow soil. While windbreaks must be planted and bush allowed to grow to protect the stream banks, by means of the exclusion of goats, a greater use must be made of dams, so that the stock may be able to utilize the pasturage over a wider area and not tread so severely the land around a few water-holes. The provision of these dams could reasonably be State or State-assisted projects.

Two American writers on "Rural Land Classification" (6) may be quoted in this connection: —

"The experience of cattlemen shows that cattle cannot be expected to make satisfactory gains where the distance they must walk for water is much greater than 1 mile. Such natural resources include springs and running streams, or streams having permanent water-holes. . . . Grazing land situated more than 1½ miles from water must be used only at times of the year when surface water is found in small holes and depressions in the land, or where additional capital is supplied for deep wells. The experience of ranchers using such land shows it to be about 25 per cent less productive of cattle than land having water, other factors being equal. . . ."

According to data quoted by Maclagan Gorrie, the maximum distance covered by cattle and sheep on the range in Texas is 6½ miles per day, with an average of 3 miles per day. The persistent goat will travel up to nearly 12 miles a day, the average distance travelled being 6 miles. These figures show that the radius from which cattle can wander away from water-holes in the dry weather is very limited. It would seem probable, however, that the light and active native cattle of Kenya travel longer distances in a day and to and from water.

The protection of water supplies and the securing of additional supplies is equally important in its relation to settlement problems, since the distribution of the population in the most advantageous way is dependent upon there being sufficient water for the people and stock which it is considered can be supported in each district. The maintenance of an ample supply of clean sweet water is of vital importance to the coffee-growing areas of the Colony, while other industries, such as the sisal industry, require large quantities of water for the factory work.

Greater populations of agriculturists can be maintained in some parts of the native reserves by an extension of the drainage and irrigation of the fertile alluvial flats or swamps which are common in many places. The extended use of these flat lands, after drainage, would enable some of the steeper slopes to be withdrawn from arable cultivation. It has been suggested in the past that an outlet for Kenya's surplus native population may be found in irrigation schemes along the Tana River, whenever the vast amount of capital necessary for the engineering works is available. However, it is known that only certain portions of the country watered by the Tana River would be suitable for the purpose of growing irrigated crops; in the meantime it seems that the rapid erosion caused by deforestation and overgrazing is rendering the land less and less suitable for agriculture and the river more difficult to use for purposes of irrigation (7).

General Conclusions and Suggestions.

I.—Land Tenure in Kenya.

(a) European Areas.

The ownership of land is not an unmixed blessing. The advantages of individual ownership over communal occupation have been mentioned, but it has often had the effect of encouraging a state of indebtedness. Farmers in many instances have locked up nearly all their capital in their land, so that they are short of working capital; or they have borrowed money in the past on the security of the land, so that they are now burdened by a heavy weight of interest charges, which prejudices their hopes of financial success in their farming operations. In either case, "land-mining" is likely to occur and neglect of proper precautions against soil erosion and loss of soil fertility; while the representatives of the mortgagees, whether the mortgage is held by a public body or private person, often check this tendency to some extent, it is nevertheless true that the above statement generally holds good, and it is often stated by farmers that they cannot afford to carry out anti-erosion measures. The country, on the other hand, cannot afford them *not* to carry out these measures, the neglect of which may be the complete and permanent loss of the land to profitable occupation.

As in other countries, farms have already been allowed to become derelict owing to these causes and effects. A solution of this problem might be for Government to lease land on short rather than on long term leases, on condition of the maintenance of good husbandry and the prevention of soil erosion and deforestation, for periods of, say, five or seven years. The yearly rent of the land could be readjusted periodically in relation to current prices for primary products, while outgoing tenants could be compensated for permanent or unexhausted improvements.

Leases would be renewable by tenants, except where there was any grave reason to the contrary, while preferential treatment would be given to heirs of tenants. Such a system, which would obviate over-capitalization and indebtedness of farmers, could not be brought into force at once in the settled areas, owing to the present investment of private capital; land which is given out for white settlement in future might be leased on such terms, however, while lands which revert to Government for various reasons might also be treated in this manner. It must be remembered that many farmers who at present ostensibly own their land are in fact in the position of tenants of their mortgagees, of the banks, or of the Land Bank, so the system proposed would not actually be a radical alteration of the existing custom.

(b) Native Areas.

The potential evils of individual ownership and agricultural indebtedness in native reserves, which were referred to by Liversage, have already been touched upon. It is evident that most difficult and complex problems are involved, which will need most earnest study if the development of the native reserves is to proceed favourably and with a minimum of internal friction.

In general it might be said that a broadly conceived plan for the development of a big reserve could be implemented better in each reserve by the co-operation with Government of a representative Central Council, with members delegated from various sections of the tribe, rather than by local councils, who would be apt to approach the question from a parochial point of view. It

would be beneficial also to bring together as far as possible smaller tribes which did not differ too markedly, racially and lingually, from their neighbours.

The main Councils, guided by Government, would be in a position to administer and protect their lands as a whole and to adjust, where desirable, local differences of density of population or of stock to the advantage of the tribe as an integrated community.

Under the present system, conditions of overstocking or over-population in sub-districts are likely to continue until these areas are destroyed completely for the purpose of human occupation, while the poverty-stricken natives in such districts will be forced inexorably by famine to seek such abiding places as shall be permitted them.

For example, if present tendencies persist, certain areas in the Kikuyu Reserve, such as those portions of land near the Kikuyu Escarpment and near Kijabe, will soon be able to support but a fraction of the population which is now resident, and will imitate the desolation of large parts of the Ukamba and other reserves. Overgrazing by cattle, sheep and goats, grass fires, the felling of trees and bush, and the cultivation of steep hillsides where shallow soil overlies a hard lava rock, are the factors which lead to social suicide.

The signs of droughted grass, drying springs and streams, and the vivid red gashes of erosion on the hillsides are the writing on the wall for administrator, agriculturist and native tribesman.

Only by centralized tribal control of both grazing and arable lands can such misuse of land be avoided; if this control be not obtained, the whittling away of the poorer parts of the reserves will rapidly accentuate the gravity of the congestion of population in other districts and deterioration even of the more fertile portions.

II.—A Survey of the Resources of the Colony.

The question of land tenure may be left, having been raised, as a subject which should be deliberated upon by persons of administrative experience. The Report of the Carter Commission dealt with this subject at considerable length.

It seems plain that, under the urge of economic progress and, it is to be anticipated, the pressure of growing populations, some modification of ancestral native custom and tradition will be very advisable in the interests of the natives themselves. The wheel of progress, now under way, must not be retarded excessively by the brake of primitive conservatism or disaster will occur. While the regularization of the methods of land tenure in Kenya would facilitate the conservation of the natural resources of the country, it is obviously essential for recommendations with this end in view to be based on a well-considered and comprehensive scheme, not only for each reserve and district in the settled areas, but for the Colony as a whole.

It is important that, as and when the necessary funds are available, a "stock-taking" should be made by a detailed scientific investigation of the use and potentialities of the land in Kenya.

The following is a suggested programme of desiderata in the field of investigation, provided that the necessary funds are forthcoming:—

(*a*) Topographic.
(*b*) Climatological.
(*c*) Ecological.
(*d*) Geological.
(*e*) Soil, with special reference to physical properties of the soil and

soil movement on various slopes and soil types.

(*f*) A survey into the present agricultural and pastoral use of the land of the Colony compared with potential development.

(*g*) A survey of the present distribution of population and live stock.

(*h*) A survey of the present extent of soil erosion of the areas which are likely to erode upon development [see (*f*)]; and of the severity of erosion in relation to the type of agriculture practised.

(*i*) A survey of the present forest area compared with the area which should be put under forest, (i) for timber, and (ii) in order to prevent erosion, to conserve water supplies and to maintain a sufficiently humid climate.

(*j*) A survey of the water supplies of the Colony, (*a*) for domestic or social purposes, including stock raising, (*b*) for irrigation, and (*c*) for power.

(*k*) A survey of areas at present under irrigation and the efficiency or otherwise of the methods employed and of the areas potentially irrigable.

(*l*) A review of the road system of the Colony in relation to the productive areas and those areas which might be developed further if transport facilities were improved.

Maps would be prepared of each district, of each province, and of the Colony as a whole, showing the details noted above. These maps would be of great value to administrative and technical officers upon whom falls the task of development; especially would the maps be valuable to officers new to their district or province. A continuity of the policy laid down by Government for developing and protecting the resources of the country in each area would be ensured.

The amenities and attractions of the country for residents and tourists, in the way of beauty spots and game reserves, would be protected by the adoption of appropriate measures, since both these must be considered as contributing directly and indirectly to the wealth of the country.

III.—Forests.

The recommendations of Nicholson have been mentioned earlier, and it is desirable that a national policy on these lines should be framed as soon as possible.

It is earnestly to be hoped that it will be found possible in the not too distant future for both Government and the Local Native Councils to find increased funds for the purposes of reafforestation; the tentative suggestion may be advanced that it might even be found feasible for a long-term loan to be raised for the specific purpose of afforestation, since it is well recognized that the forests of a country constitute sound and permanent assets. As in other parts of the world reafforestation may be a useful and beneficial way of absorbing unemployed persons or natives from overcrowded areas on work for the public good.

Several of the forests in the native reserves are run at a profit. With a developing country and improved means of transport there seems no reason why these and other native forests should not eventually yield an increased amount of direct revenue to their appropriate Native Councils in the future, in addition to the indirect benefit which would be derived.

Some means of restricting the destruction of private forests deserves consideration, while the planting and preservation

of private woodland might be encouraged by some bonus system, including, perhaps, the remission of rents on such woodlands.

IV.—Water Supplies.

The question of water supplies has been dealt with at some length. It is largely bound up with the question of preservation of forests and reafforestation. The present Water Board chiefly concerns itself with the use of water; it is essential that legislation shall be passed whereby the supplies of water shall be maintained by means of the prevention of widespread desiccation, soil erosion and excessive run-off.

V.—Organization.

It remains to note briefly the organization which would be required to carry out such a national scheme of development and preservation of the country as has been outlined.

It is possible that the situation may be found to demand the establishment of a Central Land Use Planning Committee. This Committee would collect and coordinate information and data, propose any necessary legislation, and obtain or delegate the staff necessary for the various surveys or immediate soil control work. Each district, whether in European or native areas, would have its own local committee; in the European areas this would be the District Council or a subcommittee of that body; in native areas the Local Native Councils, presided over by the administrative officer of the district or province, would be the responsible authority.

The local committees would keep in close touch with the central authority by means of reports and by visits of advisory technical experts sent by the central committee. Each district committee would have the duty of ensuring an advance along the lines laid down by the central committee as part of the national policy.

REFERENCES.

(1) Liversage, V.—"Tenure of Native Land in East Africa: The Economic Aspect," East African Agricultural Journal, Vol. I, No. 5, March, 1936.

(2) Lipson, E.—"An Introduction to the Economic History of England," London, 1923.

(3) Prothero, Rowland E.—"English Farming, Past and Present," London, 1917.

(4) Maclagan Gorrie, R.—"The Use and Misuse of Land," Oxford Forestry Memoirs, No. 19, 1935.

(5) Nicholson, J. W.—"The Future of Forestry in Kenya," Government Press, Nairobi, 1931.

(6) Kellogg, Charles E., and Ableiter, Kenneth J.—"A Method of Rural Land Classification," U.S. Dept. of Agriculture Technical Bulletin No. 469, February, 1935.

(7) Report of the Tana River Expedition, 1934.

The Unsuitability of Certain Virgin Soils to the Growth of Grain Crops

By N. V. ROUNCE, *Dip. Agric., A.I.C.T.A., Agricultural Officer, Tanganyika Territory.*

It is strikingly apparent that certain types of soils when put down to crops for the first time are entirely unsuitable in the first few years to the growth of grain crops such as maize, sorghum and pennisetum. Not only do the plants fail to produce grain, but they may fail to grow beyond half the normal height, and then abortively and prematurely attempt to break out into flower. Yet soils of these types will produce excellent crops of legumes, and also fair yields of cassava and sweet potatoes. In many areas native practice has been adjusted to contend with this; as, for instance, in Kasulu District, near Lake Tanganyika, where virgin land, especially that which has been over-oxidized by exposure to sun and weakened by sheet erosion, is invariably laid down to Bambarra groundnuts, and sweet potatoes and cassava for at least two years before any attempt is made to plant a crop of maize. Is this a question of lack of aeration, and its relation to the growth of the bacterial population? As legumes flourish in this soil, their nitrogen being fixed from the air by symbiotic organisms, perhaps the soil atmospheric conditions are unsatisfactory for the non-symbiotic organisms which enrich the soil in nitrogen in the form which can be taken up by cereal crops. It is often noticeable that sterilization caused by the burning of tree trunks, or the added aeration afforded by the root system of the felled trees, leads to a healthy development of the crop in these infertile situations, whilst the surrounding plants are all under-nourished. Experiments comparing shallow cultivation of the soil with no cultivation at all lead one to believe that the opening up of the soil, contrary to the customary native practice in Morogoro District, is of great benefit to the crops grown upon it. It would be of interest to read the opinions of those who specialize in the subject of soils as to the reason for this inhibition of growth of cereals when planted on these soils, and the best means of overcoming it and bringing the soil into good heart with the least delay.

NOTES BY G. MILNE, *M.Sc., F.I.C., Soil Chemist, Amani.*

Mr. Rounce's query may be re-stated in general terms thus: After a long period of years under undisturbed natural conditions, a soil will sometimes not respond to the exacting demands of a grain crop unless an interval is allowed for readjustment. Why?

I do not know of any direct experimental investigation of the matter as thus stated, but an answer, also in general terms, can be suggested from what is known of the requirements of a grain crop and the probable microbiological conditions. The prosperity of cereals is peculiarly a matter of well-timed nitrogen supply, and the soil mechanisms and routines that have been concerned with this element in the virgin soil suffer much disturbance at the time of clearing. During the transitional period towards a new equilibrium under the changed conditions of tillage, the supply of available nitrogen is liable to be very low at first, and not increased until too late in the season to be of use. Legumes are their own nitrogen-providers, and tuber crops,

being entirely vegetative, are more adaptable in their requirements, and (at least, in the equable temperatures of the tropics) can develop to a less rigorous time-table. Both may therefore succeed in the interim, while grain crops still find a limiting factor in operation.

The answer can only be given in a more particular form when the state of the soil is known at the time the cultivator enters upon it. This will vary so greatly according to the nature of the vegetation it has carried, and the climatic factors, that the actual causes of nitrogen shortage may be quite different in different circumstances. Of several possible cases that are implied by Mr. Rounce's examples, two at least can be shown to be liable to the result stated.

The first is the common case of a dense shade-giving, woody vegetation, cleared during hot dry weather, burned over or partially so, tilled at the first rains, and planted shortly afterwards. The organic matter of the soil is in adjustment to bush or forest conditions and to the eco-climate that they define. It consists partly of humus and partly of undecomposed vegetable residues, both at a higher level than will correspond to equilibrium in exposed arable land. The act of clearing further increases the proportion of undecomposed residues, by converting living root systems and leafage into dead matter and adding woody debris. It also lets in light and air, and greatly increases the range of fluctuation in moisture content and temperature of the surface soil. Whereas hitherto a large share in decomposition reactions has been borne by fungi and small animals (*dudus* —there is no word so good in English), the functions of these now become subordinate and bacteria multiply, taking into their own protoplasm during this stage most of the nitrogen that later on, as oxidation proceeds, will be paid into the soil's current account. If cultivation is deep and thorough, if excess woody residues are raked out, if there has been the right kind of "burn" so that ashes are well distributed without actual combustion of the soil, and if there is favourable incidence of rain and sunshine, these radical changes will proceed far during the first season. But if, for example, the cultivation is shallow and local to each planting point, the readjustments will be delayed and may be spread over several seasons, so that arable cropping is being attempted on what is still in some essentials a forest soil. Though the reserves of nitrogen are high, they are invested and not convertible at short notice; and as long as there is an excess of organic debris of wide carbon-nitrogen ratio, populated by micro-organisms not yet adapted to arable conditions, large cheques presented on the nitrogen account, as they are by a growing grain crop, will not be honoured. This state of affairs may occur during critical parts of the first growing season, more especially when a sufficient interval cannot be afforded between the first cultivation and the sowing of seed, owing to the shortness of the anticipated rainy weather. Considerations of the same kind probably apply also to other essentials to the growth of micro-organisms, especially phosphorus and sulphur.

In recent years there has been renewed study by plant physiologists of an old question, namely, the ability of higher plants to utilize forms of nitrogen other than nitrate. Most plants can take up ammonia directly, or even simple organic nitrogen compounds, in certain circumstances, though they differ greatly in response as regards growth and development when nitrogen is offered partly or wholly in this form. To some the uptake

of ammonia may be a normal, to others an unusual and physiologically disturbing experience, particularly as the plant approaches maturity. It is of interest to speculate whether the observation that sweet potatoes and cassava can make good growth on newly broken land where cereals fail, is a reflection of greater adaptability on their part in using intermediate products of protein breakdown such as would be readily available in fungus mycelium, without waiting for the services of nitrifying bacteria; whereas the cereals can only enter the nitrogen cycle successfully when it has turned to the point of nitrate production.

The second case is that of the "over-oxidized and sheet-eroded soil" such as occurs in semi-arid districts under xerophytic bush. So far from being dense and shade-giving, the vegetation here is frequently an irregular secondary coppiced growth much interfered with by grazing animals, and the soil is not virgin in the accepted sense, but has merely been out of arable use for a long time. Organic matter levels are low in respect of both humus and residues, and the bacterial population is small and, prior to cultivation, inactive. The content of nitrogen in all forms is low, and my suggestion for the cause of the delay before nitrogen-demanding crops will succeed is the same as Mr. Rounce's, namely, the time taken for the establishment of a sufficient population of non-symbiotic (free-living) nitrogen fixers. There is much evidence from the dry regions of the western United States, and some from India, that this group of micro-organisms plays a major part in the maintenance of nitrogen levels in semi-arid cultivated soils, and that the limiting factor for crop growth, more especially for grain crops, is more commonly nitrogen than what would appear to be the obvious one in such conditions, moisture. Free-living nitrogen-fixing organisms, though present, are not very active in virgin semi-arid soils, in which the processes of the nitrogen cycle must have a relatively small annual turnover. The act of tillage stimulates them to activity, but their multiplication must depend on supplies of energy-yielding carbohydrate. Of this the soil itself can offer little, but the root residues of two or three seasons' legume and tuber crops may well supply the deficiency. Another point of importance is that these organisms have a restricted reaction-tolerance on the acid side and do not flourish when the soil is below pH 6. Semi-arid soils as a group tend to be neutral or alkaline, but are not necessarily so if their parent materials have been exhausted to a low base status during some earlier cycle of weathering. The plateau regions of East Africa offer many examples of acid soils under a semi-arid regime, and a season or two's incorporation of the alkaline ash from a good "burn", or of basic crop residues, may be a necessary preliminary to efficient nitrogen supply.

In the foregoing, the most likely means of bringing a newly broken soil early into good heart have been indicated. They include deep and thorough cultivation in good time to allow an interval of favourable weather before seed sowing, and other practices of good husbandry which are, however, often unfamiliar or impracticable to the African cultivator. The deferring of a grain crop until after one or two harvests of pulses and tubers is no doubt an unconscious adaptation of agricultural method to the necessities of soil biochemistry, the limitations of poor tools, the risk of loss of seed in a bad year, and so on; but is it not perhaps in part, with some tribes, a price paid for choosing the easiest way?

It would be of interest to know whether instances can be adduced of "grain-crop failure the first year" from districts such as Usukuma, where the inhabitants are not afraid of hard digging; or from experimental farms under European supervision, where the preparation of the land may be supposed to be carried out at its best. The collection and publication of well annotated examples of the effect would in any case contribute much to the understanding of the practice of shifting cultivation in its various circumstances. The unfavourable conditions of nitrogen supply discussed above cannot be supposed to be a *general* consequence of the breaking of new or long-disused land for arable use, but rather they are a possible contingency, and may occur in certain conjunctions of type of soil, type of bush cleared, clearing methods, burning practice, cultivation, time-table of planting in relation to rains, etc. It would indeed be contrary to general experience to say that grain crops are *generally* avoided in the first season. Thus the two recently issued works on West African agriculture, by Faulkner and Mackie (1933) and by Irvine (1934), make no mention of it in their sections on shifting cultivation, nor does the Agricultural Survey of Central Nyasaland, by Hornby (1935), which is largely concerned with native agriculture. The analysis, in some detail, of the conditions in cases both of failure and of non-failure of first crop cereals would seem desirable if the matter is to be better understood.

Latex Test for Maturity of Papaya Fruits*

The immature fruit of the papaya (*Carica papaya*) contains the enzyme papain. The concentration of this enzyme in the juice reaches its maximum when the green fruit is fully grown in size, and then decreases as the fruit matures, apparently disappearing when full maturity is reached. As the papaya fruit matures the following changes are readily apparent: colour of the flesh and placentæ changes to orange or peach pink, depending on variety character; the seeds turn black; the flesh softens, and its sweet taste increases with a decrease in effective acidity (increase in pH). The colour of the juice also changes with maturity. When the immature green fruit is punctured a milky juice is exuded. The milkiness of the juice becomes less and less as maturity proceeds, until the stage is reached when the fruit matures on the tree and the juice exuded is colourless and finally ceases to exude at all. When fruits capable of exuding juice are cut in half, the exudation following the puncture rapidly declines, beginning near the cut end and ending finally on the ridge farthest from the cut surfaces.

Preliminary observations indicate that the change in colour of the exuded juice may be used as a maturity test, and that the best time to harvest the fruit is when the exuded juice has become almost or wholly colourless. Earlier picking results in an inferior product, and later picking reduces the keeping quality.

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Report on a Visit to Southern India and Java

Part II.—The Coffee Industry of Java (N.E.I.)

Conclusions and Recommendations

By S. GILLETT, *Dip. Agric. (Wye), Agricultural Officer, Kenya Colony.*

FOREWORD.

This section of the report deals with the general aspect of coffee-planting in Java, with special reference to the methods adopted by the several experimental stations for the improvement of the crop. The information was obtained during a seven weeks' concentrated study of the crop in the principal coffee-growing areas of the Island.

INTRODUCTION.

The history of the coffee industry of Java since its inception is of special interest, as it shows how the introduction of new varieties or selections has always had the foremost consideration in combating diseases and pests. An endeavour to find a resistant variety rather than to attempt remedial measures on the type already planted has always been the policy of the Dutch planters, and the results obtained by their work convince one of the strength of their policy.

Coffea arabica was first introduced into Java from India towards the end of the seventeenth century. From these original plants was built up the immense arabica coffee industry which thrived until the end of the nineteenth century. At this time, poor cultural methods, the ravages of leaf disease and eelworm, and also, according to the Director of the Besoeki Experiment Station, a peculiar star-flower formation of the inflorescence, made the growing of *Coffea arabica* below an elevation of 3,000 feet impossible.

Attempts were made to replace *C. arabica* with *C. liberica* in these low-lying areas, but it was found that this species was also susceptible to leaf disease. Hybrids, however, between *C. arabica* and *C. liberica,* known as the "Kalimas" and "Kawasari" hybrids, helped to stem over a period of difficult years until *Coffea robusta* was introduced at the beginning of the twentieth century.

Only a few years elapsed before it was realized that this species was eminently suited to the conditions, and extensive breeding and grafting work was immediately commenced by Dr. P. J. S. Cramer at the Government Experiment Farm at Bangelan. It can be claimed that the results of his early work have been taken as the foundation on which the present-day investigations are being based.

GENERAL CULTIVATION, SOILS AND MANURES.

Before discussing the work being conducted on the improvement of coffee, it will perhaps be well to give an account of the conditions and estate methods adopted.

The majority of the coffee areas consist of rich volcanic soils, and in consequence manuring has not as yet reached a stage of great importance. There was evidence that certain *robusta* estates were benefiting from an application of nitrogenous manures, but there were no yield results to show whether the application had been economical or not.

The few remaining *arabica* estates are situated inside and on the outer slopes of the Idjen Plateau. There the soil is of more recent origin, and coffee has been growing for over forty years without the application of any manure. On Blawan Estate, a new area was being opened for planting at the time of the writer's visit.

Here the soil is of such recent origin that a few inches below the surface there is a hard crust of completely unweathered material. This land is opened up two years before it is desired to plant coffee, and *Tephrosia vogelii* is planted. The roots of this crop tend to penetrate the hard crust, causing rapid weathering. Even then, when holing is being carried out, it is necessary to bore below the crust and fill in with good soil so that the young plants may be given a good start.

The other soils, although very porous, appear with the assistance of heavy shade and consequent leaf mulch to retain moisture satisfactorily. The rainfall on this estate averages between 50 and 60 inches per annum, but a long drought of between four to six months is experienced during the period of crop maturity. The greatest importance is attached to the maintenance of a good canopy of shade during the period of drought, in order to conserve the soil moisture.

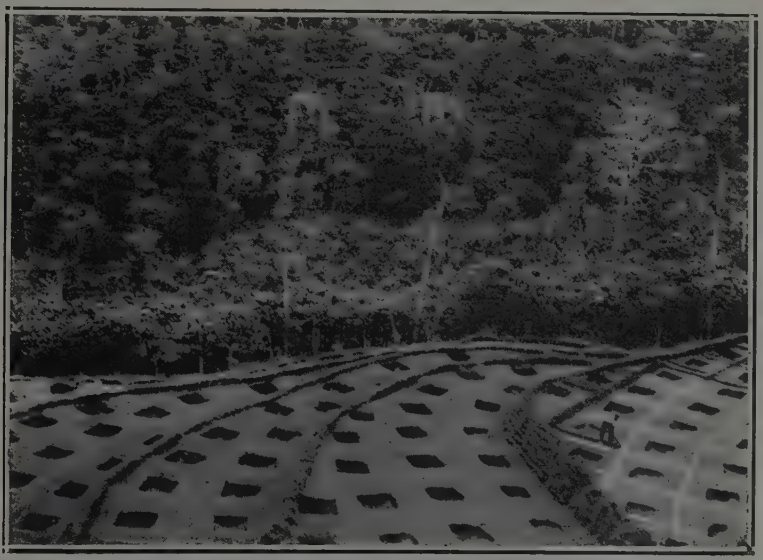
Weeding is practically the only cultivation performed. Only on one estate visited was deep cultivation being practised, and this was being carried out on a small area for trial purposes. Cover crops are to found on some of the *robusta* estates, but are not liked for *arabica*.

Shade.

Leucaena glauca (Lamtoro) is the shade tree of the country, and is considered to be by far the best so far tried. The trees are planted close together, and kept pruned up, producing a bushy growth at their summit. This growth is not what would appear to be the most beneficial method of shade-tree pruning, but it is simple, and is the system adopted by all. On the Government Experiment Station at Bangelan, Lamtoro is planted one to every coffee bush to commence with; after about three years it is thinned out, leaving one to every two coffee bushes, and finally one to four. On the *arabica* estates this tree is supplemented by *Erythrina lithosperma* at the higher elevations. Either of these trees is recognized by the growers of *arabica* coffee to be a good lower shade, but they claim that a higher shade, such as *Albizzia moluccana*, is of very great importance, especially as a control against their mealy bug, *Pseudococcus citri*. This was most apparent on Kalisat Estate, where the previous manager had felled what was stated to have been a magnificent high shade canopy of *Albizzia moluccana*. Almost immediately after their removal the ravages of *Pseudococcus citri* did untold damage, and when the writer visited this estate several hundred acres had been completely ruined, including the famous experiment garden. The present manager is replacing this tall shade as quickly as possible, but it will take many years before the damage done can be repaired.

Planting, etc.

The Dutch planter here can teach us much. He realizes that the tree he plants is to remain an investment throughout his life, and accordingly makes certain that everything possible is done for the plant in the early days. First and foremost, the preparation of the land. No rushed methods are here employed; the planting requirements for the following year are prepared in good time. The land is cleared and dug, and then, without exception, some suitable method is taken to prevent soil erosion. The method adopted depends according to circumstances, but whatever system is carried out it may be relied upon to be 100 per cent efficient. The holes for planting are dug at least one year before required. They are usually made one metre cub. After holing, the whole area will be sown



Terracing and preparation of the land prior to planting, Java.

Terracing and preparation of the land prior to planting, Java.

with a green manure such as *Tephrosia* sp. or *Crotalaria* sp. Some few months before planting the coffee, the green manure is pulled up and stripped of its foliage. This foliage is mixed with good soil and possibly cattle manure and placed in the holes, where it is allowed to settle prior to planting. *Leucaena glauca,* in addition to its use as a shade tree, also makes an exceedingly useful low hedge, and is often used on the sides of terraces to prevent washaways. This is planted either as soon as the land is terraced or at the same time as the coffee is planted. The writer was more impressed with its value from this standpoint than from that of shade.

Clean planting is generally practised, but basket plants are sometimes used when the plants are large. In the majority of cases it is necessary to shade the plants after planting out. Nursery selection of plants is now generally practised, poor plants being discarded at once, and not left to be planted later. "Once a weak tree always a weak tree" is the belief in Java.

While it must be admitted that labour is cheap, the cost of the preparation of the land from cleaning to planting is extremely reasonable. The cost, including a special method of terracing, was stated to be 70 guilders per bouw (Sh. 67 per acre approximately). Figures for land which did not require such expensive terracing were very much less. When once established, the cost of upkeep is practically nothing.

Terracing and preparation of the land prior to planting, Java.

There still appears some doubt as to the advisability of the use of cover crops. Selective weeding is practised on a fairly large scale, and seeds of some of the known good indigenous weeds are often collected and planted in the plantations. The use of indigenous weeds rather than introduced leguminous crops is preferred. A wild salvia is being extensively used in one district, but this would not appear to

be generally suitable; in fact, in one area harmful effects from this crop were most apparent.

Pruning.

Little need be said of the methods of pruning the *robusta* species, as they could not be applicable to the *arabica* species. Actually, in general practice, there appeared to be little systematic pruning; individual trees would receive different treatment, according to their requirements. Certain systems do, however, predominate. These are either the single stem system, a form of the multiple stem system, and the "candelabra" system. The last mentioned is not being widely adopted. Pruning in general entails the removal of dead wood, and little attention is paid to the shape of the tree.

The system of pruning the *arabica* sp. on the Idjen Plateau is of more interest. Here the tree is allowed to grow on the single stem system to a height of about 5 ft., and is capped. The growth of the wood maintained on the tree is exceedingly whippy. A bayonet is encouraged from the top of the tree, and allowed to grow upwards and produce crop. This bayonet remains until there are signs of dieback either on it or on the tree. At this stage the bayonet is cut down, and the tree allowed to recover prior to allowing the growth of another bayonet. It is maintained that the best quality coffee is obtained from the bayonet. Handling and centering is carried out, and a certain amount of the old wood is removed, otherwise little pruning is performed.

Picking and Factory Manangement.

In Java, all coffee is completely prepared for export on the estate. Consequently the factories are much larger and more equipment is required than in the case of the East African factory. This complete preparation has its advantages, since the manager is able to follow up differences in cultural practices, fermentation and curing more easily than if he only handled the material during half its process of preparation. One striking feature of the picking in Java is the sorting of the cherry by the pickers before it is received in the factory. The cherry, in other words, is carefully graded before pulping. The ripe cherry is passed through the factory in the ordinary way, whilst the green and half-ripe cherry is passed through a "cracker" and dried out as *mbuni* coffee. This operation, which costs nothing, since the pickers, who are engaged on piecework, have to sort before their wages are paid, ensures that only fully ripe cherry is passed into the fermenting tanks.

As regards pulpers, the most popular for *robusta* coffee at the present time is undoubtedly the "Vis" pulper. Although the writer was not fortunate enough to see one actually at work, he was told that it was a most efficient machine. It is estimated that only 3 to 5 per cent of the pulp passes through into the fermenting tank. The Director of Government Plantations was of the opinion that with *robusta* coffee the "Raoeng" pulper was undoubtedly the most efficient, but owing to its price and the high power and quantity of water required to drive it, it was not an economic proposition at today's prices. No one would, however, commit himself as to its merits for *arabica* coffee, since it is fully appreciated that the preparation of this species presents a very different problem. Actually, the same type of pulper as is found in Kenya was in use on the *arabica* estates. These were mostly old machines, and although they were stated to be preferable to the "Vis" for *arabica* coffee, the writer could find no instance where proof of this had

been obtained. The fermentation of *robusta* coffee is carried out rather more by the clock than by the stage of fermentation. If the process is not completed, it will be finished off in the washing machine. Little importance is attached to fermentation. Sulphate of ammonia is often added to the coffee in the fermenting tanks in order to speed up fermentation. On the *arabica* estates, however, more attention was paid, and although the coffee was usually passed through a washing machine after fermentation, it was seldom removed from the tank until the process was completed. Fermentation under water and under running water is practised on some estates, but is not general.

After washing, the coffee is allowed to drain on raised perforated iron sheets for a few hours prior to placing in the drying house. Although several types of driers are in use in Java, and others are in the experimental stage, the one most commonly found is the drying house. This is a building having a raised floor of perforated iron sheets on which the coffee is spread. The heat, supplied by a furnace at ground level, is carried evenly underneath the whole of the raised floor by means of large pipes. A roof encloses the building, but ample ventilation below the heat pipes and above the coffee is of the greatest importance. The process of drying is one to which a great deal of importance is attached, and one in which the treatment of *robusta* and *arabica* coffee differs very widely. Managers of *robusta* estates claimed almost without exception that the colour of the finished article depended entirely on the drying and not at all on the fermentation. Some claimed that they could make a coffee either blue or yellow according to the method of drying. If the coffee was dried at a temperature of 170° F., with plenty of ventilation, a yellow-green coffee, such as is to-day's market requirement, is obtained; whilst, if it is dried at a temperature of 120° F., with no ventilation in the drying house, a blue coffee results.

As regards *arabica* coffee, Mr. Lunt, the manager of Blawan Estate, a planter with many years' experience of *arabica* coffee in Java, stated emphatically that the best method for drying *arabica* coffee is sun drying, and that if a drier is employed on no account must the temperature exceed 120° F., this temperature gradually being reduced as the coffee becomes drier. If higher drying temperatures were employed, the colour of the coffee would be adversely affected.

After drying, the coffee is graded and finally very carefully hand sorted. This operation is as carefully carried out in Java with the low-priced *robusta* coffees as it is in India with the higher priced arabians, showing the importance once again attached to the marketing of the crop.

The Methods of Improvement of Coffee: Organization.

As with other crops in Java, the greater part of the experimental work conducted on coffee is financed by private organizations. Previously each station was controlled by the local planters' organization. Recently, however, there has been a co-ordination of research, with the result that the coffee, rubber and tea experimental stations now come under the direct control of a General Agricultural Syndicate. In Java there are two main coffee experimental stations—the Malang Experiment Station at Malang, and the Besoeki Experiment Station at Djember. A third station at Salatiga in Middle Java has, due to lack of finances, been practically closed down, and is being continued only as a small sub-station.

The Malang station is situated in the centre of a large *robusta* area, and the work conducted at the station is mainly concerned with the improvement of this species. Attached to the station in Malang there is a small experimental garden where important selection work is carried out; whilst twenty miles away, at Soember Asin, there is a large experimental coffee plantation.

The work at the Besoeki Experiment Station can be classified under three main headings:—

(*a*) The improvement of the *arabica* species growing on the Idjen Plateau;

(*b*) The breeding and selection of varieties suitable for the intermediate altitudes between 2,000 and 3,000 feet;

(*c*) The improvement of the *robusta* species.

It is fully realized by the scientific officers of the Experimental Stations that on selection and kindred work little can be accomplished without the co-operation of the estate managers. It was the close co-operation that existed which struck the writer most forcibly. In the Besoeki District, a district which has approximately twice the area of land planted to coffee that Kenya has, there are twenty-five sub-stations on private estates. Each sub-station is cared for by the estate manager in close co-operation with the officers of the experiment station, and the general appearance and the work being conducted on the several sub-stations visited cast very great credit on all concerned.

In addition to the experiment stations under the control of the General Agricultural Syndicate, the Department of Agriculture has at Bangelan a large experimental farm which has been in progress for the last 35 years.

Improvement of *Robusta* Coffee.

1.—*Selection and Hybridization.*

The early work, which was commenced at the Government Station, Bangelan, and continued by the other two stations in their early days, was the selection of individual trees on plantations. In addition to keeping very accurate records of the yield and behaviour of these trees, seeds and grafting material would be taken from them and plots established on the experiment farm. At Soember Asin, the experimental farm for Malang, sufficient grafting material is taken from the selected parent to establish a plot for ten trees. These will suffice to keep close records of behaviour, to compare with similar plots from other parent trees, and for material for hybridization if required. Such grafts are always established on the ordinary standard type of seedling material commonly found in the district. This is important, as if the selection proves worthy of issue it will be grafted on to such material on estates, and the behaviour of the tree on a specially selected stock might not give comparable results. In addition to grafted plots, seedling plots are also established, if possible using selfed seed. These seedling plots are also of great importance, as it is found that certain parents breed almost pure from seed and do not behave well as grafts; whilst others are especially suited for grafting but may split up into many types when propagated from seed. Hence observations of both seedling and vegetatively propagated material must be made. The seedling plots, in addition to their value mentioned above, also produce material for further selections. The station now contains such a wealth of material that it is no longer necessary to carry out selection work on estates.

At the Government Farm at Bangelan the same procedure is adopted, except

that the original grafted and seedling plots are slightly larger, and, in addition, larger plots of between 49 and 100 trees are established as soon as possible to supply grafting material and seed for issue as soon as the selection is proved. With some of the proved selections, hectare monoclonal plots of grafted material have been established for the production of seed. These plots are of special interest, since it was due to the very low yields obtained, on account of the self-sterility of the *robusta* species, that grafting as a general practice received a severe setback.

It is stated that no selection should be recommended for general planting until ten years' records have been kept.

Dr. Hille Ris Lambers, the Selectionist at the Malang Station, informed the writer that he did not entirely favour the selection of old mother trees, on the grounds that their apparent vigour, etc., was not necessarily an inherent character of the plant, but often due to some outside cause, and in consequence grafted material taken from such a tree may not maintain the character of the parent. He prefers a combination of hybridization and selection; in other words, making crosses of trees having good qualities and selecting the progeny obtained. By this method the study of the tree can be made from its youth.

In his work on hybridization with *robusta*, Dr. Hille Ris Lambers no longer emasculates the flowers on the tree selected to be the female parent, but covers the whole tree up prior to flowering. Pollen is collected in quantity from the male parent and dusted over the whole female parent. Should any of the seeds be self-fertilized the young seedlings are readily recognizable in the nurseries and discarded. He was of the opinion that this method was worth a trial with *arabica*. The writer, however, feels that the percentage of self-fertilized plants with this species would be too high to be practicable. Trees, even if selfed, are always given an artificial watering, in order to encourage flowering earlier than their neighbours, so that fear of possible outside pollination is avoided.

At Besoeki, Dr. Schweitzer, in addition to carrying out work similar to that described above, has adopted another line of work which appears to have distinct possibilities. A large number of crosses have been made, using the best selections as parents. The progeny from these crosses have been planted out in plots on the experimental farm, and their behaviour, yield, etc., closely watched. When the progeny of a certain cross has been proved and further seed of it is required for distribution, it is intended to plant up an area of the two parents, vegetatively propagated, in a forest clearing. As *robusta* is practically self-sterile, the seed obtained will be the result of natural crossings. Owing to the almost complete self-fertility of the *arabica* species, this practice could not be adopted, but grafting material taken from the original plots would be a quick method of reproducing the type, and is worthy of consideration.

It is fully realized that, however good a selection may prove to be on one of the experiment farms, on no account can it be recommended for general use until it has been tested out in the various districts. A good selection in one area may prove worthless in another. A very good example of this was found on one estate where 50 bouws (1 bouw = 1¾ acres) of land had been planted with an exceptionally good selection at the experiment farm. Under the different climatic conditions of the estate, although the trees appeared vigorous, practically no crop was obtained. It is here that the co-

operation between the scientific organizations and the estate managers plays such an important part in the progress of the selection work, and is indeed an essential factor if the work is to proceed with any rapidity, which it most certainly does in Java.

Selection work does not limit itself to the establishment of high-yielding, good quality trees, but also plays an important part in the control of diseases and pests. It appeared highly probable that the ravages of the shot-hole borers (*Xyleborus morigerus* and *Xyleborus morstatti*) may be much reduced in the near future by the selection of types showing marked resistance.

2.—*Grafting.*

When it is realized that approximately one-third of the new plantings in Java to-day is of grafted material, the importance attached to this line of work can be appreciated. Whilst this method of propagation is increasing in popularity yearly several problems connected with it remain to be solved before the practice becomes general.

Dr. Hille Ris Lambers believes that the influence of the "scion" is of much greater importance than that of the "stock" It must be admitted that he has strong grounds for this belief, as in many cases poor trees had been converted into strong, vigorous ones by top grafting with selected vigorous material. On the Soember Asin farm a plot of very poor soil had carried a mixed seedling population for a number of years with poor results. It was decided to uproot one-half of the plot and plant again with seedling material from a known selected tree; the other half was stumped, and clonal graft wood of the same selected tree grafted on to them. The grafted area is now a uniform high-yielding block, indicating most definitely in this instance that the influence of the stock had been almost negligible; whereas the seedling block consisted of a most variable population.

Nevertheless, in one district visited it was obvious that the influence of the stock could not be entirely neglected, and it is felt that whilst the influence of the scion may predominate in certain cases that of the stock must be taken into account. For instance, the Government Station at Bangelan has found that their selection Rob. 124-01 is a better stock for top-grafting *robusta* varieties on to than many others tested out, and it is now entirely used by the station for seedling grafts. Thousands of seedlings of this selection are raised annually for use as stocks. Grafted plants are sold in large numbers to estates. The price per plant varies from 15 to 25 cents of a guilder (1 guilder = 1s. 8d. at par). It would appear that the stock and the scion should be closely related. For instance, *robusta* grafts do better on a *robusta* stock than they do on an *excelsa* stock, and the Kawasari D hybrid, an *arabica-liberica* hybrid, does better on an *excelsa* stock (*excelsa* falling among the *liberica* group) than it does on a *robusta* stock, etc.

Cleft grafting is the only method used. With old stocks the grafts are made on to young suckers encouraged from the base of the tree. In some districts grafting can be carried out at any time of the year, but in others the percentage of success obtained during the different months varies considerably. The best time of the year for grafting is when the tree commences active growth after a rest period, but before the sap flow is too prolific. In the more humid areas it is only necessary to protect the graft and all cut surfaces with grafting wax; in other areas a waxed paper cover, as recommended for use in Kenya, is necessary. On the Soember Asin farm red waxed paper covers were

being used with greater success than the ordinary plain ones.

The cleft grafting of branches, or what is known as branch grafting, is becoming a very popular practice on estates for the rejuvenation of individual trees. It is maintained that the two chief enemies of coffee are wind and sun; wind damaging the coffee trees and the direct rays of the sun affecting the soil. By branch grafting a very much quicker spread is obtained, thus affording a rapid cover to the soil. The technique for branch grafting is similar to that of the ordinary graft, except that the sucker to be grafted is encouraged from the top of the main stem instead of at its base, and the scion used is lateral wood instead of vertical. Owing to the marked polarity of coffee, the type of lateral wood used is an all-important factor, and so also is the type of tree from which it is taken. Some types of trees will only give graft wood which develops into a squat habit of growth, whilst others produce trees which when established would be difficult to differentiate from an ordinary vertical graft. Another important factor in favour of branch grafting *robusta* is that the period at which infestation from the branch borer is most likely to occur is greatly reduced owing to the rapid maturity of the branch. It is usual in Java to put some distinguishing mark, such as a red band or paint, round the union of all grafted plants. This enables all sucker growth from the stock to be determined early and removed.

Grafted *robusta* plantation, Soember Asin Estate, Java.

Turning now to the methods adopted by estate managers for the improvement of their existing coffee by vegetative means, it is worthy of note that the manager of Tretes Panggoeny Estate, Mr. Houtsmuller, has increased his production over a large area from 11 to 18 piculs per bouw in three years (1 picul = 136 lb.; 1 bouw = 1¾ acres) by top grafting weak trees. It is a general prac-

tice on many estates to observe the productivity of individual trees over a period of years. When it is determined that any one tree is a low yielder, it is immediately stumped and grafted with material from a known high-yielding parent. On another estate, Wonokoye, the manager, Mr. Koch, is also rapidly improving his productivity by grafting poor yielders with scion wood from selections made and recorded on his own estate. Here eight boys are kept solely for grafting work.

Whilst undoubtedly vast benefits are being derived by many from this method of propagation, it must be stated that on some estates visited the growth of top grafted trees was disappointing and did not appear to be showing much uniformity. Whether this was due to the influence of the stock, incompatibility, the use of scion wood from unsuited trees, or other causes, it is too early to say, but it does indicate that there are many factors which still remain to be investigated.

Improvement of *Arabica* Coffee.

As previously mentioned, the area which remains under *arabica* coffee in Java is extremely small, and it is therefore not unnatural to find very little work being conducted on the improvement of this species. The work is confined to private estates on the Idjen Plateau, and is conducted under the close supervision of the officers of the Besoeki Experiment Station. Variety trials play an important part in the investigational work in progress, and it is of special interest to note that the Harar type, the same as that which promises so well in Kenya, is outstanding. At the time of the writer's visit the plants were young and no yield figures have as yet been obtained, but in vigour and growth they surpass all other varieties under trial.

Certain hybridization work is also in progress, and that which is worthy of special note is the crosses that have been made between *C. congensis* and *C. arabica*. *C. congensis* is practically immune to leaf disease, its productivity is good and its habitus, while the bean and the taste of the coffee are closely allied to *C. arabica*. The crosses made appear to maintain the appearance of *C. arabica* as far as the bean and the leaf are concerned, but the growth is more vigorous and the tree is also strongly resistant to leaf disease.

Pantjoer Estate, which was visited, is full of interest, as it was here that Ottolander carried out much work on *arabica* coffee in the early days. Unfortunately, he died without leaving records, and in consequence much of the valuable work he did has been lost. Many different types of *arabica* coffee are to be found scattered about the estate. The original trees of *C. arabica columnaris* are very vigorous and worthy of trial as a stock for grafting purposes. *C. arabica erecta*, which was also discovered on this estate by Ottolander, and recommended for steep slopes and wind-swept sites, has not found favour, and appears of little value.

The technique for the hybridization of the *arabica* species, as practised by the Besoeki Experiment Station, is as follows: The female parent is emasculated about two days prior to the opening of the flower bud. This is done by removing the corolla tube carefully so as not to damage the stigma. The prepared branch or branches are then covered with a bag of butter-muslin or other material. The flower buds required from the male parent are also covered prior to opening with a similar bag, in order to prevent

risk of foreign pollen being present. On the day that the flowers are fully open a cluster of them is removed from the male parent and lightly brushed over the stigmas on the prepared female parent. On completion, the female parent is covered up for a further period of four days.

Work of Selection of Types for Intermediate Altitudes.

In addition to the work already mentioned, the Besoeki Experiment Station is testing out different strains suitable for planting at altitudes between 2,000 and 3,000 feet, an area which is too high for *robusta* but too low for *arabica*. The best selection so far obtained is known as "Conuga"; the original plant is believed to have been the result of a natural cross between *C. congensis* and *C. robusta* (Uganda). Unfortunately, no purity can be obtained by propagation from seed, and in consequence it has to be raised vegetatively. There was proof on several estates visited that it is well suited to the conditions for which it has been selected. On one estate where the original *robusta* plants were only yielding 3 piculs per bouw, Conuga was producing as much as 12 piculs.

General Investigational Work.

While selection, breeding and vegetative propagation claim a large percentage of the time of the research officers, other factors connected with coffee culture are not neglected.

Some of the most important points receiving attention are:—

(1) The effect of climatic conditions on the incidence of flowering.—Dr. Schweitzer, who has been conducting extensive research into this problem, has formulated the opinion that the incidence of flowering depends almost entirely on the climatic conditions prevailing previously to the bursting of the flower buds. He declares that the determining factor is the water content of the leaf prior to flowering. If the moisture content of the leaf is low, flowering will occur; whilst, if it is high, vegetative growth will be produced. Hence the importance of small-leafed types for the wetter districts; large leaves assimilate more moisture and do not fall during the dry weather to the required low moisture content to encourage flowering. Whether the water content of the leaf is actually the controlling factor, or whether other physical conditions of the tree, brought about by the low water content of the leaf, are the deciding factors has yet to be proved, but it is obviously a line of work worthy of consideration. The theory would appear to be supported by the importance attached to "wintering" in South India and to a condition which prevailed in the Federated Malay States last year and is mentioned in Part III of this report.

(2) A study of the percentage of flowers which actually set and produce a mature bean.—One of the chief difficulties with *robusta* coffee, owing to its self-sterility, is to ensure natural cross pollination. Figures obtained show that in many cases not more than 20 per cent of the flowers develop into a mature bean. It has been found that certain selections cross-pollinate more freely than others, and it is believed that the ease with which such selections pollinate one another has a direct bearing on the percentage of spongy or empty beans obtained. Work at Bangelan is proceeding in order to determine which selections should be interplanted in order to obtain a maximum of fertilization.

(3) Shade and cultivation experiments are also being conducted. Neither has been in progress for a sufficient length

of time to produce definite results. In the cultivation experiment, designed to test out different methods of cultural practices, one of the treatments consists of digging a trench annually one metre from the tree, about one metre long and 25 cm. deep. The object of these trenches is actually a root pruning. Dr. Ferwerda, the Director of the Bangelan Station, is of the opinion that in general there is an excess of vegetation to crop, and by a limited root pruning hopes to restore the balance.

(4) Another interesting experiment is being conducted at the Besoeki Experiment Station. This consists of a trial of twelve indigenous weeds used as cover crops as compared to clean weeding. The trees are still young, but the increased growth of those on the clean weeded plots is most marked, and measurements taken show that there is a significant superiority in growth of them over all other treatments.

(5) Manurial trials conducted by the staff at Malang have given few results, with the exception that increased yields have been obtained by the use of cattle manure and compost. As already stated, nitrogenous dressings appear to be advantageous in some areas, but no yield results have been obtained.

(6) *Mealy Bug.*—During his tour, the writer took the opportunity of discussing with several entomologists the possibilities of the introduction of beneficial parasites for the control of the Kenya mealy bug (*Pseudococcus kenyae*). Dr. Van der Goot, the Java Government Entomologist, who has spent many years working on the control measures for different mealy bugs, expressed the opinion that it was a line worthy of the fullest investigation, but felt that we might have to import many species before a successful parasite was obtained. He felt that the genus *Pseudococcus* had never been fully identified, and that there were actually many more strains of it than had been already classified. Dr. Van der Goot promised the writer that he would collect and forward to Kenya as many likely parasites as he could. It is hoped that these will arrive in the near future. He was also of the opinion that a search should be made in Hawaii, an island which is very rich in beneficial parasites.

ACKNOWLEDGMENTS.

It would be impossible to mention all those who assisted to make my visits to India and Java of such interest. In India, thanks are especially due to the Director of Agriculture, Bangalore, for allowing a study of the work in progress on the Experimental Farm to be made and for other kindnesses; to Mr. Wilson Mayne, the Coffee Scientific Officer of the U.P.A.S.I., for arranging a comprehensive tour and for much valuable information and hospitality; and to the President and members of the U.P.A.S.I. for immense assistance. Finally, heartiest thanks are due to the many planters who so kindly extended hospitality to me. In Java, thanks are especially due to the Director, Dr. Gandrup, and officers of the Malang Experiment Station; the Director, Dr. Schweitzer, and officers of the Besoeki Experiment Station; and to the Manager, Mr. Russeh, and the Geneticist, Mr. de Vries, of the Government Experiment Station, Bangelan, for their unstinted assistance. Finally, thanks are due to H.B.M. Commercial Agent, Batavia, Mr. L. B. S. Larkins, for his helpful guidance throughout, and to many estate managers for much information and hospitality.

Conclusions and Recommendations.

While the writer feels that the tour has been invaluable for a host of reasons,

certain factors would appear to stand out as being applicable to Kenya conditions and therefore warrant further consideration. These may best be summarized as follows:—

1. Outstanding importance is being attached to selection and breeding, and, closely linked with this, vegetative propagation of all tropical crops. Whereas it is fully realized that cultural treatment, including manuring, assists to bring out the inherent characteristics of a plant, it cannot under condition change those inherent characteristics. Thus, once a bad plant, always a bad plant. If cultural treatments convert a weedy plant into a strong, healthy plant, then it merely means that the plant is genetically productive, but had succumbed to bad treatment. Unfortunately, with most tropical crops, the variability in seedling material is so great that every population of plants contains a percentage, often high, of genetically weak plants. No cultural treatment can change this state. Selections and/or breeding, with the assistance of vegetative propagation, can alone produce a clonal population of high-yielding good quality material.

In addition, every crop is expected to grow under varying climatic conditions. The type suitable for one district cannot be expected to be suitable for all. Trials of different varieties and types may produce the desired results, but it is more likely that good selections taken in the various areas are a safer line on which to work. This is most striking in Java with the work on coffee.

Finally, the importance of this work as a means of combating pests and diseases must be stressed. This point is clearly shown by the splendid progress made by Mr. Mayne in Southern India, where, during the course of a few years' careful investigations, he has succeeded in breeding a type showing complete resistance to both physiologic forms of the leaf disease (*Hemileia vastatrix*).

The value of selection and vegetative propagation work has long been realized by the Coffee Section of the Kenya Department, and valuable progress has been made by the staff available. The writer is convinced, however, that the subject is worthy of much greater attention than it has been possible to give it in the past, and recommends that more time should be allotted to the investigational officers engaged on coffee for this work. Such work must entail the closest co-operation of the planters. Small sub-stations on private estates in the different districts would have to be opened, the upkeep of which should not fall entirely on one individual, but should be collectively assisted by all in those districts.

Nevertheless, until we can be more certain of the behaviour of trees propagated vegetatively, it would be necessary to propagate small plots of all selections from seed, by grafting and by cuttings. These should be established in the districts in which the selections are made and at the Scott Agricultural Laboratories. In addition, the yield and general behaviour of all selections must be kept for a period of years.

Further, investigations should be proceeded with as quickly as possible, in order to establish a simple technique for grafting in the field on to old stocks. In some areas this will present few difficulties, but in others difficulties will appear which can only be overcome by repeated trials. When a method is evolved, great improvements in yield and other characters can be expected by top-grafting established plantations.

Finally, much work remains to be carried out at the Scott Agricultural Laboratories and other stations before many problems connected with vegetative propagation can be elucidated.

2. The very great influence that carefully regulated tree shade has on the control of diseases and pests and in the prevention of over-bearing, resulting in improved quality in *arabica* coffee, is observable in both Southern India and Java. It has long been realized that tree shade would be beneficial in many districts of Kenya, but it has been difficult to recommend its use owing to a lack of knowledge of the behaviour of different trees in various areas. Issues of trees for trial have been made by the Coffee Section in the past, but it is felt that the planter has been slow to realize the great benefits that would accrue if the matter was treated with the serious attention that it deserves. The best trees for the various areas can only be determined by extensive trials: that suitable trees exist cannot be doubted. The tendency in the past has been to give shading a trial, using one tree only through the plantation, instead of extending the trial to a number of different trees.

Having seen the influence of good shade in Southern India, the writer feels that a large majority of planters would be well advised to consider more seriously the possibilities of tree shade in this country, especially in certain areas where diseases of physiological troubles occur.

3. While it is realized in South India that spraying with Bordeaux mixture is far from being an efficient control against leaf disease (*Hemileia vastatrix*), its actual efficiency depends very largely on the time of application of the spray. No hard and fast rule can be laid down, but the time of application must vary annually with the different climatic conditions. Success with Bordeaux spraying against leaf disease in Kenya has not been great, and it is felt that a study of the local conditions, on the same lines as carried out in India, would prove most beneficial. It must be remembered that Bordeaux mixture only acts as a protective, and therefore application before infection is essential. With this in mind, the correct times of application should be determinable and spraying should prove as effective in Kenya as it is in India.

4. Apart from the research work conducted in Java, the general feature which strikes the visitor most forcibly is the sound agricultural practices adopted by the planters. Much benefit would undoubtedly accrue to the coffee industry of Kenya if their example of careful and most thorough working was followed. First and foremost, the steps taken against soil erosion. Secondly, the preparation of the land prior to planting. It is realized that if the tree is given every opportunity in its youth to develop a strong, healthy foundation, it will be capable of carrying its early crops without strain, and in consequence develop into a strong, healthy tree. Thirdly, the careful rejection of all nursery plants showing a tendency to weakliness. Lastly, the general use of grafting for the improvement of existing plantations.

5. The exceptional care taken with grading and hand-picking in order to ensure a first-class article for the market is a special feature of plantation work in both South India and Java. Even with low-priced *robusta* coffees, the necessity for producing the best possible article for the market is realized. With the high quality Kenya coffees this factor might receive more attention.

6. The carrying out of experimental work on individual estates or at all costs in the different districts is regarded as of great importance. The close co-operation which exists between the planter and the experiment station staff is an outstanding feature in Java, and is undoubtedly responsible for the great progress being made.

The Influence of Forests on Climate and Water Supply in Kenya.—Part II.

By J. W. NICHOLSON, *formerly Forest Adviser to the Governments of Kenya and Uganda.*

CHAPTER III.

Forests and Rainfall: The General Controversy (Continued).

Having attempted to minimize the possibilities of forests inducing precipitation, Dr. Brooks goes on to consider the extent of the local effect of forests on rainfall. He prefaces his views by rightly drawing attention to the fact that "There is often an appreciable difference between the *fall* of rain, i.e. the amount which would fall on the site of the rain gauge if the latter were removed, and the *catch* of rain, or the actual amount recorded by the gauge. This is due mainly to the action of wind, forming eddies over the top of the gauge, which carry away some of the falling raindrops instead of allowing them to drop into the gauge. The effect is dependent on the wind velocity, which is the reason why the catch of rain decreases with the height of the rim of the gauge above the ground. Hence on a site exposed to strong winds the ratio between the catch of rain and the true fall will be smaller than in a sheltered position; the former gauge is said to be over-exposed. Obviously the chances of over-exposure are very much greater on an open plain than in a forest clearing, and this is one of the main reasons why the catch in clearings is usually greater than at neighbouring open stations. To be comparable, the height of the rim of the gauge above ground in a forest clearing should be about four times that in the open."

Dr. Brooks then proceeds to classify the various forms of precipitation. For our purposes, as we are not concerned with snow, hoar frost, etc., we can simplify his classification, and, placing them in the order in which they will be dealt with below, the classes of precipitation are as follows:—

(1) Occult precipitation, namely deposit of moisture from fog or dew.
(2) Cyclonic rain.
(3) Orographical rain, or, as more familiarly known in East Africa, "monsoon" rain.
(4) Instability or continental rain.

Occult precipitation is partly due to the condensing capacity of forests, which is induced by the dampness of the air within forests. In many tropical forests the condensing capacity is so great that during every clear and still night drops of dew fall continuously from the leaves as in rain. Occult precipitation is further due to the mechanical action of the trees themselves. When a cloud in the mountains passes through a forest the branches and the leaves of the trees retard its movement. It comes therefore into a state when it can no longer retain its moisture in suspension, just as a river carrying sediment deposits part of it as soon as the rapidity of its flow is diminished. The moisture from such clouds is intercepted by the forest in the form of mist or drops of dew on the branches and foliage of the trees. Dr. Brooks regards the subject of such occult precipitation as very obscure, owing to the difficulty of measuring dew and fog drippings. He quotes various investigations. One experiment was conducted by Wartch, who exposed two five-inch rain-gauges on Table Mountain, one in the ordinary way

and one under reeds, fixed in such a way that any moisture which was deposited on them dripped into the gauge. From 31st December, 1902, to 15th February, 1903, the first gauge collected only 4.9 inches of rain; the second, the enormous quantity of 79.8 inches. This result is very striking, but it has been pointed out that the water caught in Marloth's reed gauge is almost entirely water which would otherwise have reached the ground to leeward, and therefore this mechanical action cannot add appreciably to the effective supply of rain-water. Another investigator, Descombes, quotes the case of two neighbouring basins in the Pyrenees, otherwise similar, but one wooded and the other bare, the run-off from the first being twice that from the second; and he calculates that the "occult precipitation" over the forested area must be more than three times the ordinary rainfall. He gives similar figures for other basins. More recently, Phillips' investigations at the South African Forests Research Station have shown that occult precipitation can amount to at least 25 per cent. of the annual rainfall.

Dr. Brooks sums up the matter by stating that owing to the smaller annual variation of temperature within forest areas, it does not seem probable that the deposition of dew from trees can greatly exceed that on grass in meadows, which has been found in England and Germany to amount to about an inch of water in the course of the year. He further states that the mechanical effect of a forest in collecting moisture from enveloping clouds is limited to the windward edge of the forest, and is practically negligible away from the edge. The writer is convinced that Dr. Brooks is under-estimating the amount of occult precipitation in forest areas. The writer's observations of conditions in India and East Africa have shown that certainly when the dry season is setting in there is far more dew in the immediate vicinity of forests than on exposed grass, and, further, one has only to walk through a forest enveloped in clouds to know that condensation is not confined to the windward edge. We thus lose further confidence in our meteorological acquaintance, Dr. Brooks.

Our third conclusion is that, under favourable circumstances, mountain forests in East Africa can induce occult precipitation up to at least 25 per cent of the total annual rainfall.

"We come next to cyclonic rain. Cyclones are mainly generated over the ocean, and their development cannot possibly be influenced by the forested area on land. In temperate regions they show some tendency to follow tracks over the oceans rather than the land in winter, and vice versa in the height of summer, and it is conceivable that the deforestation of very large areas of land might make some slight difference to the frequency and intensity of depressions over the continents. The differences of temperature and humidity between forest and cultivated land are so small in comparison with the differences over ocean and continent as to be negligible, and the only possible influence would be due to friction between air and surface. Last century it was even suggested that the deforestation of North America, by allowing cyclones to sweep across the country without hindrance, contributed to the (supposed) deterioration of the climate of Europe, but this view need not be taken seriously. In fact, when we consider the vast scale of forces in operation in an ordinary barometric depression, it does not seem probable that changes in the amount of forest, even over several thousand square miles, can

have any appreciable effects. In any case, the matter is beyond proof, and is best left out of calculation."

With these words of Dr. Brooks there are few that will disagree. Further, in Kenya, so far as is known, little rain is due to cyclonic disturbances, the latter confining themselves to areas of the Indian Ocean.

Our fourth conclusion is therefore that forests have little or no influence on cyclonic rain, and that the problem does not concern Kenya.

Orographical or monsoon rain is due to wind currents passing over rising land. Dr. Brooks states that a forest can obviously be regarded as adding to the effective height of the land. He quotes investigations in various countries which indicate that an increase of 33 feet in height causes an increase of about one inch of rain. He also refers to the checking action on wind which even a low forest may induce in comparison with an open level plain, because the uneven surface of the vegetation offers much greater friction. The same volume of air moving more slowly has to occupy a greater depth, and there must be some ascent of air. He states that the amount is difficult to evaluate, but as an extreme case he supposes that one-tenth of the air which passes through the lowest fifty feet over the plain is transferred to an average height of five hundred feet above the forest. This gives an effective increase of elevation of fifty feet, giving an increase of rainfall of about two per cent. He then quotes another possible effect of forest, which depends on the slightly lower temperature of the surface of the ground and the crowns of the trees in forests compared with open plains. The air passing over the forest will be cooled slightly by conduction compared with passing over the plain, and therefore its capacity for heat will be lowered. He considers that the amount of cooling by conduction is negligible compared with that by expansion due to elevation, and he sums up by estimating that the total increase of rainfall in temperate countries due to the orographical effect of forests is not more than three per cent. He further points out that this does not necessarily mean a gain of that amount to the water resources of the country, as in the case of a forested lowland backed by bare hills the amount gained on the lowland will be lost on the hills unless it is given back to the air as evaporation or transpiration.

Dr. Brooks backs up his views by references to several statistical investigations which show that if the catch of the rain is equalized for forest clearings and open sites, the net effect of forests in increasing orographical rain is limited to one to two per cent of the rainfall.

Experience of monsoon rains in countries such as India goes to show that Dr. Brooks is correct in minimizing the effects of forests on such rain, and his estimate of a maximum effect of three per cent is very possibly correct for the temperate climates. In the tropics the effect may be greater, as tropical forests in many cases raise the effective height of the land by 150 feet or more. Further, in hot countries, the effects of forest in inducing condensation of moisture are likely to be greater than Dr. Brooks has indicated. However, if Dr. Brooks is correct so far as local effects are concerned, what about regional effects? Dr. Brooks makes a reference to forested lowlands backed by bare hills, and states that a local increase of rain over the forest areas does not imply a gain in rain to the whole region *unless it is given back to the air as evaporation or transpiration.* His last remark is very significant. It does not matter

whether it is a case of a forested lowland backed by bare hills or of a continuous level stretch of forest. Winds cannot continue to deposit moisture indefinitely unless it is replaced. Let us quote from Zon on this subject: "As long as air currents remain saturated with moisture, the slightest cooling or irregularity of the land that causes them to rise will result in precipitation. But as they move inland and become drier the remaining moisture is given off with difficulty and precipitation decreases. The sooner the humid air currents over land are drained of their moisture, the shorter, of course, is the distance from the ocean over which abundant precipitation falls. If precipitation depended solely on the amount of water brought by the prevailing winds directly from the ocean, rainfall would, of course, be confined only to the narrow belt close to the sea. Not all the water that is precipitated, however, is lost from the air current. A large part of it is again evaporated from the land into the atmosphere. The moisture-laden air currents therefore soon lose the moisture which they obtain directly from the ocean, but in moving farther into the interior absorb the evaporation from the land."

We have already shown that forests, especially in regions where the rainfall is seasonal, usually contribute more moisture to the air than other forms of vegetation. Hence the greatest contributions of moisture to monsoon winds will usually come from forested tracts, and the latter can therefore exercise an important regional influence on rainfall. This influence is more likely to be exercised in moderately level than in mountainous countries, as high mountain chains themselves exert an influence upon precipitation and wind direction. In the particular instance of lowland forest referred to by Dr. Brooks there *would* be a gain to the water resources of the country.

Our fifth conclusion is that in the case of monsoon rainfall the local effect of forests on rainfall is limited to a maximum of about 3 per cent, but the regional effect may be far greater.

CHAPTER IV.

Forests and Rainfall: The General Controversy (Concluded).

Lastly, we come to instability rain, which deserves a chapter to itself. Instability rain is due "to the warming up of the surface layer of air to a point at which it is potentially higher than the air above it. The potentially light air begins to rise, at first in thin threads, which produce scattered cumulus clouds, and finally, if the process continues far enough, in thicker columns which cause cumulo-nimbus clouds, with rain and perhaps thunder and hail. The potential density of the air depends mainly on its temperature and partly also on its humidity." It is thus that Dr. Brooks describes instability rain, but we can add a few further remarks to supplement his description. In East Africa, instability rain falls on still afternoons, usually after bright, sunny mornings. It is frequently accompanied by thunder, and is always very local in its distribution. In some parts of Uganda, to lessen the contingency of crops failing, the natives cultivate two *shambas*, some miles apart from one another. Unfortunately, the European cannot copy this practice, but where the instability rain is the prevailing form of rainfall he can select a long-shaped in preference to a square-shaped farm.

Dr. Brooks minimizes the possible effects of forests on instability rain. Firstly, he states that there is little difference between forest and cultivated land

as regards humidity. This is an opinion we have already challenged, as we know it is incorrect for East Africa. Secondly, he states that the air over bare ground, especially rock, on calm summer afternoons must be several degrees warmer than over either field or forest. Quite so, but we are concerned with rain, not with dust, and unless there is moisture in the rising air we will not get rain. Dr. Brooks sums up by stating, "There is some possibility therefore that the replacement of forests by crop or grass land would slightly increase the frequency of instability showers, while their replacement by bare soil would have a more marked effect, but it is quite impossible to form any estimate of the amount." A year's sojourn in the Solai Valley might materially assist Dr. Brooks to estimate the amount!

The only statistical investigations which Dr. Brooks quotes in connection with instability rain are those which were carried out in Mauritius by A. Walter.* The latter worked out the rainfall over a period of years in forested and deforested tracts, and he expressed the conclusion that "forests appear to increase the probability that rain will fall during the afternoon, on calm days." Dr. Brooks challenges the correctness of Walter's conclusions, and states that there was a change in the character of the local circulation over the Island, and that the decrease of pressure shows that some general factor has been in operation besides deforestation. This may or may not be the case, but from the discussion which followed Dr. Brooks' paper it would seem that Dr. Brooks himself was prepared to accept Walter's conclusion.

What other evidence have we of the effects of forests on instability rain? Zon quotes many cases in which he considers it has been proved that forests induce rain, and some of these cases may be of instability rainfall. Unfortunately, as he failed to distinguish between the different sources of rain his instances are rather valueless. With one exception, the further evidence in favour of forests influencing instability rain consists of non-statistical observations by the writer. The exception consists of the case of the eucalyptus plantations on the Nilgiris in India. In a report on "The Improvement of Indian Agriculture," by Dr. Voelcker (1897), it is stated in this connection: "Taking all the months of the year except June, July and August (which are excluded because the rains of this period are not local in origin, but are those of the south-west monsoon and come from a distance), it was found that during the treeless period, 1870-74, there was a total of 374 rainy days only, while during the wooded period, 1886-90, there were 416 rainy days. Further than this, it was ascertained that the character of the rainfall had altered within late years, light and regular rain showers taking, to a great extent, the place of destructive occasional torrents. The agricultural importance of these facts is very great indeed." In his evidence, given before the recent Agricultural Commission in India, the Inspector General of Forests brought Dr. Voelcker's figure up to date, and gave the following figures:—

Period.	*Excluding June, July and August.*
1870-74	374 rainy days
1886-90	416 „
1902-06	467 „
1918-22	481 „

He adds: "It thus seems clear that the number of rainy days in the Nilgiri Hills has increased with the increase of forests on those hills. On the 467 rainy days in 1902-06 the rainfall was 165 inches; on

* Now Director of the British East African Meteorological Service.

the 481 rainy days in 1918-22 the rainfall was 177 inches."

As evidence that deforestation may result in a decrease of rain, the writer would quote the case of his last district in India—Ranchi, in Chota Nagpur. About 50 years ago, when the district was well wooded, instability rain was fairly frequent during the hot weather, and at that time several tea gardens were opened up. During the last half century the forests (which were private) have been destroyed. There is no evidence to show that the monsoon rainfall has been affected thereby, but so serious has been the decrease in instability rain that tea gardens can no longer in-fill and they are dying out.

Further evidence that forests induce instability rain consists of observations made by the writer in Uganda. The rainfall in Uganda has generally been assumed by writers interested in the hydrology of the Nile to be of monsoon origin, and incidentally Dr. Brooks seems to share this opinion (*vide* his paper, "The Distribution of Rainfall over Uganda, with a Note on Kenya Colony, 1924"). The writer is not a meteorologist but all the data he has been able to collect is to show that most of Uganda's rainfall is not of monsoon origin but consists of instability rain. The evidence that this is the case need not be gone into here, but it may be mentioned that in parts of the Belgian Congo—that mythical source of much of Kenya's rainfall—which adjoin Western Uganda the evidence is similar that most of the rainfall is instability rain.

The evidence that forest vegetation in Uganda influences rainfall is as follows: Along the eastern boundary of Uganda, from Mount Elgon to the Sudan frontier, runs the plateau of Karamoja. This was once an inland sea, and the disappearance of the waters has left black cotton soil plains. Black cotton soil is not a soil capable of supporting a proper forest vegetation—as probably few people in Kenya need to be told.

Along the western edge of the Karamoja Plateau the soil changes to a sandy loam, and as soon as the change occurs we find true forest vegetation, although of an open savanna fire-resistant type. Now it is a remarkable fact that, whereas the Karamoja Plains enjoy a rainfall of only 20 to 25 inches a year, the forest tracts to the west enjoy a fall of 40 to 50 inches. In September and October, 1928, the writer spent several days on the border line, and every afternoon the clouds gathered and rain was precipitated westwards of the line demarcating the grassy plains and wooded tracts. Now there are small ranges of hills along the demarcating line, but otherwise the country is very flat and there is no conceivable reason why the rainfall should suddenly increase unless it is due to the fact that it is the forest vegetation that is inducing rain. That they should do so is not to be wondered at, as we have already shown that instability rain ought to be engendered by forests, but the wonder is that the difference in rainfall should be so very remarkable.

Other evidence in Uganda is afforded by the country to the immediate west of Victoria Nyanza. The lake level has receded considerably during the last few centuries, and it has left behind flats which here and there cannot support deep-rooted vegetation, owing to the physical character of the soil. In the south-west, near Sango Bay, there is a fairly large stretch of forest, extending into Tanganyika and penetrated by such occasional forestless flats. Observers at the forest station situated in this forest state many storms occur over the forest

which do not occur over the grassy glades. Further, in Uganda the prevailing direction of instability storms is from the east or north-east, and one finds that the country to the west of the large woodless flats receives far less rain than that to the west of the wooded areas or papyrus swamps. Two interesting facts may be noted: Firstly, although near the lake the humidity is high and grass does not go through periods of drought, nevertheless the wooded areas receive most rain. This seems to show that tropical forests of the type there prevailing do contribute, contrary to the assumptions of Dr. Brooks, more moisture to the atmosphere than grasslands. (*Note.*—Swamps may be regarded as equivalent to forests as moisture producers.) Secondly, the effects of forests, swamps and lakes in inducing instability rain appear to be extremely local. In fact, as one proceeds westwards from the forest or lake edge the rainfall drops at the rate of about 1½ to 2 inches per mile.

The assumption that forests induce instability rain is to some extent confirmed by evidence in Kenya—this will be dealt with in the next chapter—but owing to the presence of mountain ranges affecting the conditions of instability rain in Kenya the evidence is not so convincing as that of Uganda. Taking the evidence of India and Uganda together, there seems to the writer to be no doubt whatsoever but that under certain conditions forests can and do exercise a most powerful influence in inducing instability rain. We say "under certain conditions" as it would be folly to draw general conclusions, in the way that Zon and Dr. Brooks do, and state that forests always induce instability rain.

Our sixth conclusion is that, wherever meteorological conditions in East Africa are favourable to the production of instability rain, the possibility and quantity of such rain is greatly increased by the presence of forests.

(*To be continued.*)

Suggestions to Managers of Ginneries

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STEAM POWER PLANTS.

Before lighting the fire, a responsible person should make sure that the level of water in the boiler is not below the low-level mark.

When raising steam from cold a slow fire only should be made, and a period of time, not less than 5 to 6 hours, should be allowed to reach full pressure.

During running the gauge glasses should be blown down at frequent intervals, and gauge cocks tested.

If, on any occasion, water is not visible in the gauge glasses, do not start up the water feed pump or injector, but draw the fire and allow the boiler to cool down before adding cold water.

Fusible plugs should be renewed every year and kept free from scale.

When using dirty feed water the boiler shown be blown down at least once daily. This should be done before attempting to raise steam, so that the sediment that has settled during the night will be discharged. Never blow down with more than 20 lb. pressure in the boiler.

The safety valve should not be allowed to corrode on its seat. It should be lifted at frequent intervals to ensure that it is free.

The feed water pump should be set to give the required amount of water. The practice of letting the water fall to a low level in the gauge glass and then rapidly filling up with cold water is injurious to the boiler and uneconomical in fuel.

The smoke up-take should be in good repair; corroded, cracked or perforated sections are dangerous.

The main steam valve must be efficient and capable of completely shutting off the steam.

A loose flywheel key is extremely dangerous and must have immediate attention, as also should slack main and large-end bearings and cross-heads.

INTERNAL COMBUSTION ENGINES.

The exhaust system should be in good repair; corroded pipes and leaking joints are dangerous.

SEED COTTON OPENERS.

These machines should have their various pulleys and gears efficiently secured on their respective shafts.

All the gears, pulleys and drives should be guarded.

There should be an efficient strap-fork on each machine, the handle of which should be within easy reach of the person feeding the machine.

The dust chutes should be large and free from acute bends. They should be arranged to discharge outside the ginnery and should be capable of being easily removed for cleaning.

The two cleaning doors under the spiked rollers and the hand cleaning doors in the fan up-take and housing must be an airtight fit.

Attention should also be given to any space there may be between the base of the machine and the floor; all spaces should be securely sealed with pieces of hessian. Leakage of air at these points destroys the object of the fan; consequently dust is discharged together with the cotton, instead of passing up the chute.

Ginning Machines.

Rollers must be free from holes and must run true. Each roller should have a uniform diameter. Their bearings must be a proper working fit, and their driving pulleys must have metal guards covering their driving belts.

The fixed knives must be in good condition and correctly set, i.e. the chamfered side of the knife must be away from the roller and the knife-edge level with a horizontal line from the centre of the roller.

The moving knives must be in good condition and set to suit the cotton staple.

Knife connecting-rod bearings (top and bottom) and crankshaft bearings must have no slack which allows of up-and-down movement.

The back, front and side sheet-metal covers of the gins must be in position, and should fit closely.

The fixed knife rails must have guards fitted to prevent seed-cotton or seed from bouncing over into the lint.

The feeder boards must be free from protrusions (nail and screw heads, etc.) and crevices that are likely to cause seed breaking.

Seed grids must be in good condition and free from bent and broken prongs.

The gins must be solid and secure on their beds to prevent their jumping about when working.

All gins should be numbered consecutively, the figures to be painted in white on the fixed knife rails.

Oil cups and other lubricating devices must be clean and serviceable.

Gins must run up to speed.

Each gin must have an efficient belt-shifter that will remain where placed without the aid of pieces of wood, etc.

Seed-cotton platforms behind the gins should be so arranged as to prevent unginned material falling down amongst the seed.

Baling Presses and Pumps.

The press head must have no movement on its columns; and the columns no movement in their base.

Control valves and pipe-line joints must be efficient and, in the case of the former, free from excessive leaks.

The press pump must be efficient in its operation, with its low-pressure glands properly packed and its high-pressure leathers in good order. Its low-pressure knock-off valves must operate correctly.

All bearings and fast and loose pulleys on the pump must be efficient.

The pump must have a belt-shifting gear.

The pump gears and other danger points must be guarded.

The pump must be securely installed.

Miscellaneous.

Electric wiring joints must not be left exposed, but should be suitably wrapped.

Wiring must be suitably secured to any part that carries it; string as a means to this end is unsuitable.

Floors must be safe and free from loose or rotten boards.

All obvious danger points, water wells, holes, trenches, platforms, shaft-ends, pulleys, belts, gears, etc., must be suitably guarded.

Rat-proofing devices of cotton product stores must be efficient. Large stones, steps or boards permanently fixed near to and below their doors, trees or other growth, articles and refuse, barriers, tables, or chairs within six feet of their walls, are not permitted.